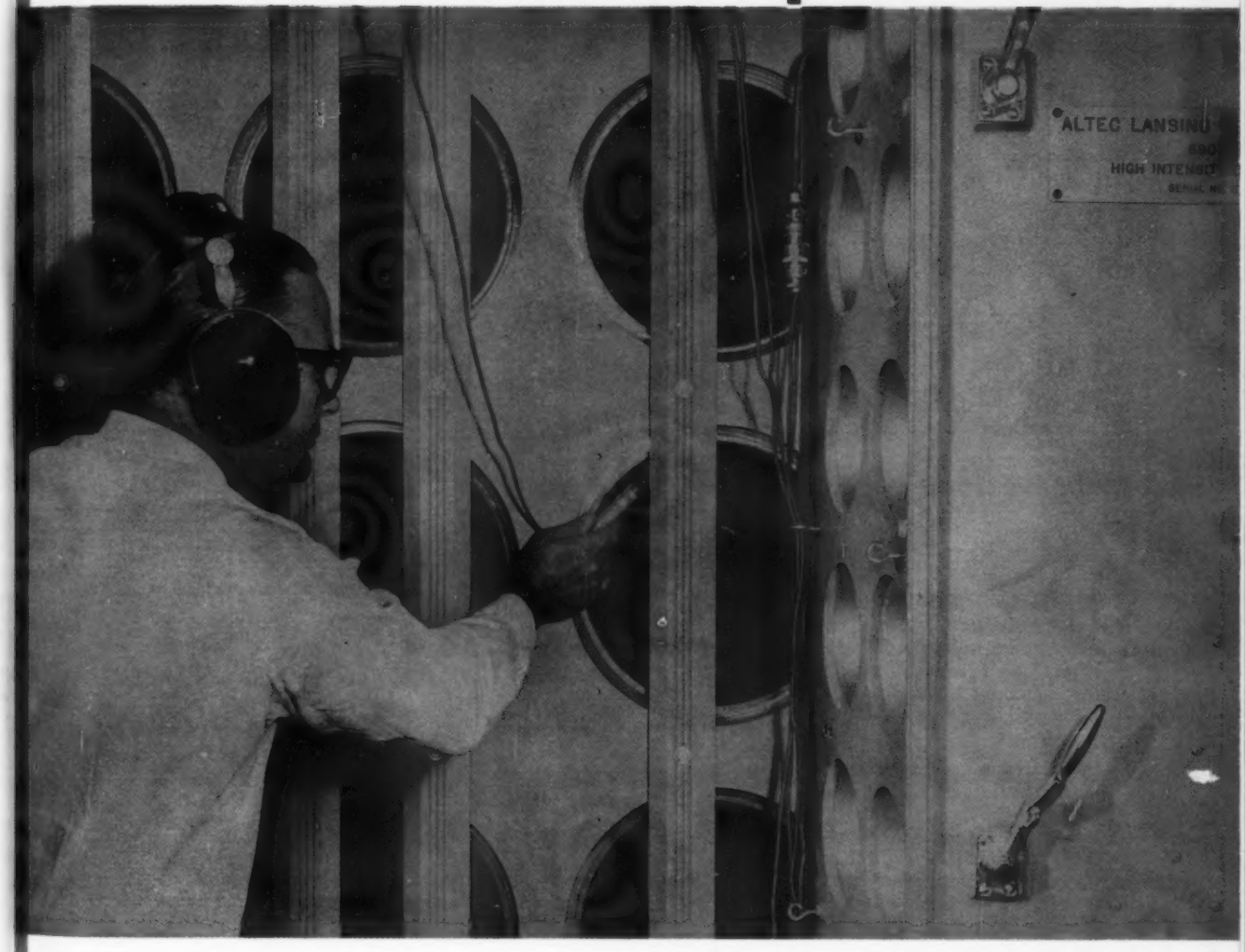
ENVIRONMENTAL QUARTERLY

JULY • 1959

The Pioneer Space Age Publication of Environmental Simulation, Testing, Engineering and Equipment Manufacturing

INDEPENDENTLY PUBLISHED

Volume 5 • Number 3



High Intensity Sound

a destructive, powerful force...

a useful, versatile tool!

The destructive forces of high intensity sound—both in vibration and heat produced—are now better understood and better controlled through the use of testing chambers such as this latest Ling-Altec Reverberation Chamber.

Here, an Engineer adjusts one of the monitoring microphones in a chamber that can produce over 150 db of white noise—enough to equal the noise spectrum of the most powerful modern jet engines.

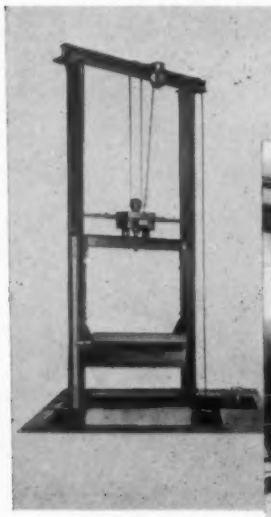
Even greater forces can be produced in Ling-Altec Plane Wave Tubes with air modulated devices which concentrate the power of high intensity sound many times.

These developments are a part of the continuing leadership of the Ling-Altec combination—high power electronics and high intensity sound!

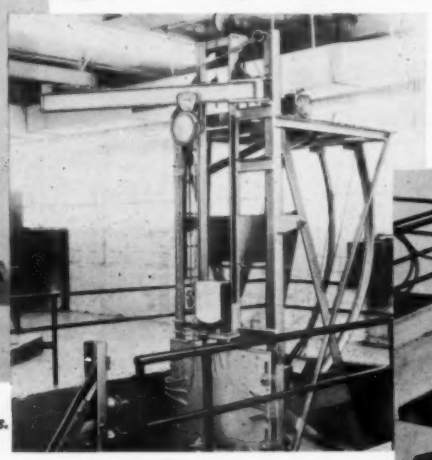
LING ELECTRONICS, INC.

Factory Sales Offices: 9937 West Jefferson Boulevard, Culver City, California
1515 South Manchester Avenue, Anaheim, California
120 Cross Street, Winchester, Massachusetts

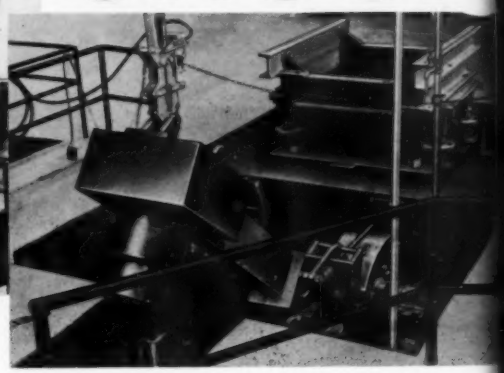
BELOCK tests for SHOCK SHOCK SHOCK



Drop Tester
Specimen weights to 400 lbs.
Peak accelerations to 77 g's
Applicable to:
MIL-E-5272A
MIL-E-5400A
MIL-T-5422C



High-Impact Shock Testing Machine for Light Weight Equipment
Specimen weights to 400 lbs.
Two 400 lb. hammers
Certified by U.S. Navy
Applicable to MIL-S-901B
MIL-T-17113



High-Impact Shock Testing Machine for Medium Weight Equipment
Specimen weights to 4,000 lbs.
Peak accelerations to 1000 g's
Hammer weight — 4000 lbs.
Table travel pneumatically controlled
Certified by U.S. Navy
Applicable to MIL-S-901B
MIL-T-17113

The Belock Environmental Testing Laboratory, one of the newest and most modern in the East, has facilities for shock testing components and assemblies weighing from 0.4 to 4,000 lbs.

Shock testing is only one of the many services offered at Belock. The Environmental Laboratory has complete facilities for testing your finished product under all static and dynamic environmental conditions:

at temperatures from —100°F to +300°F and at altitudes from 0 to 100,000 feet

under accelerations up to 1000 g's

during vibrations up to 2,000 cps at 0.3 inch peak to peak displacement.

Sun, rain, sand, dust, fog, and salt spray can also be simulated.

A wide variety of electrical, electronic, pneumatic, hydraulic, and thermal measuring instruments are available for measurement of all required parameters during test. Complete programmed control systems allow automatically controlled test periods lasting from a few hours to several months. Adequate power is available for conducting tests with variable voltage d. c., and 60-cycle and 400-cycle, single- or three-phase a. c.

The facilities of the Enviro mental Laboratory are back by the Belock engineering sta a publications departmen photographic department, an IBM statistical section to he you carry out any comprehensi testing program you may desi A completely equipped machi shop is available for constru tion of all fixtures and moun ings required for your tests.

For a brochure describing our complete facility, call HIckory 5-4200 Ext. 369 or 370, or write —

BELOCK ENVIRONMENTAL TESTING LABORATORY
Belock Instrument Corporation
College Point, 56, New York, N. Y.

LOW COST CENTRIFUGE

for large-quantity acceleration test programs

Genisco Model A903 features simplified operating procedures; rugged construction...for fast, accurate testing to MIL-E-5272A, Procedure II

Although the A903 is a simple, low cost centrifuge, it has many features found in more sophisticated machines, *plus* unique features which particularly suit it for production-line testing and evaluation programs.

SIMPLE OPERATION—Except for an on-off switch, controls are limited to a single handwheel which controls table speed. Chance of human error is reduced to a minimum. Test personnel can learn its operation in minutes.

SPEEDS TESTING—24" diameter mounting-table will accommodate several test objects. Arranged symmetrically, they can be subjected to acceleration forces simultaneously.

RUGGEDLY-BUILT—Virtually immune to operational abuse. Will operate for long periods without maintenance as demanded for production test programs.

0.5% ACCURACY—Constancy of rotation of the mounting-table is within 0.5%, including wow and drift. Table rotation speed can be measured electronically within ±1 count.

BRIEF SPECIFICATIONS

G-Range: 1 to 1,000 g's in five standard ranges, infinitely variable

G-Pound Capacity: 2,500 g pounds, maximum

Constancy of Rotation:

Wow: 0.5%, maximum

Drift: 0.2% of rate per minute, maximum

Speed Indication Accuracy:

Tachometer: ±1¼%

Magnetic Pickoffs: 60 tooth pickoff gear standard; 600 tooth gear optional. Pulses are fed to a front panel coaxial receptacle for use with any standard electronic counter.

Vibration Isolation: 0.1 g in any plane, at any speed

Test Object Dimensions: 8" high (24" diameter circular platform)

Slip Rings: 8 standard, 10 amp. maximum

Write for complete technical information and prices.

Genisco INCORPORATED

2233 FEDERAL AVENUE • LOS ANGELES 64 • CALIFORNIA

Post Scripts

We Gotta Crow . . .

. . . a risky business at best, because sometimes you find you gotta eat it. But . . .

Herewith the third issue of the new, independent **Environmental Quarterly**, the biggest single issue of any magazine ever published in the environmental field. This is particularly gratifying, not only because it is evidence of Quarterly's steady growth in editorial and advertising content since coming under independent ownership, but because it reflects the growing importance of environmental science and industry.

The environmental trade show in Chicago last April—uniquely recreated for you in this issue with two full pages of pictures (See Pages 19 and 22)—is one piece of evidence of this growth. Another is the confidence the investing public is showing in environmental business (See Page 34).

More and Better than Ever

There are other signs, too. Despite the "dog days" of the summer season, this issue of the new Quarterly shows still another increase in paid advertising space—evidence that those who help create environments have new and exciting stories to tell (and, happily, that Quarterly has proved itself as the medium for their message).

Finally, for evidence of the tremendous strides being made in developing advanced tools and thinking for simulating environments, turn to this issue's feature articles and the "New Products" department, which starts on Page 12. Never have so many new products been reported on in a single issue of an environmental publication.

A New EQ Service: Want Ads

Looking for a job or trying to find a better one?

Seeking the right man for a key position?

Need to locate some special equipment or service?

Offering a professional service or non-environmental service in the environmental field?

Environmental Quarterly is pleased to announce that henceforth it will carry certain kinds of classified advertising under the heading: ENVIRONMENTAL WANT ADS. This feature generally will appear on the "New Products" page.

For complete rates and rules write to "Environmental Want Ads," Environmental Quarterly, P. O. Box 2583, Grand Central Station, New York 17, N. Y. Want ad information will not be given by telephone.

Environmental Wants Ads will be free of charge to engineers, salesmen and others seeking positions in the environmental industry who adhere to a prescribed wording and who demonstrate that by background, education or experience they can reasonably expect such employment.

(For anyone preferring to write his own "situation wanted" ad the first three lines are free.)

For others, the charge is $5 for the first three lines and $2 for each additional line, with payment in full accompanying order.

A "line" contains about 25 characters—roughly three-fourths as wide as the line you are now reading.

If you want a coded address it will be supplied, but your order must contain complete name and address. Replies will be

(Continued on Page 33)

ENVIRONMENTAL QUARTERLY

The Pioneer Space Age Publication of Environmental Simulation, Testing, Engineering and Equipment Manufacturing

JULY • 1959 Vol. 5 • No. 3

Inside This Issue

ARTICLES

The Seismic Shock and Vibration Pickup

by John H. Armstrong and George Stathopoulos, Naval Ordnance Laboratory, White Oak, Md.

A comprehensive analysis of the theory and practice of shock and vibration instrumentation.

Task Equipment Analysis and Environmental Testing

by Max A. Pape, Stanford Research Institute

Before a component can face the rigors of natural environments, it must survive a few created by man.

Power Spectral Density Nomogram

by Roy W. Mustain, Norair Division, Northrop Corporation

Lord Rayleigh can take some credit for this absorbing statistical exercise in random vibration.

SPECIAL FEATURE

The Environmental Equipment Trade Show in Pictures 19, 2

If you were there or if you weren't, here's a pictorial report on the industry's annual exposition.

DEPARTMENTS

EQ'S ALBUM • An exclusive feature of the new EQ •
In environments, too, a picture speaks a thousand words

AROUND THE ENVIRONS • An exclusive feature of the new EQ •
"Chicago Equation" and other notes of interest to those who work with environments

ENVIRONMENTAL BUSINESS • An exclusive feature of the new EQ •
Investors smile, companies expand and the EEI selects Harris on the commercial and industrial side of environments

LITERATURE FOR ENVIRONMENTS • A special report by the new EQ •
A digest of latest informational material

NEW PRODUCTS • A special report by the new EQ •
Photos and text about devices to improve environments

PEOPLE YOU KNOW • A special report by the new EQ •
News of those who have changed their environments

POST SCRIPTS • A report from the editor of EQ •
Announcing a new EQ service: ENVIRONMENTAL WANT ADS (*also see Page 12*)

INDEX TO ADVERTISERS • A regular feature of the new EQ •

Environmental Quarterly, the pioneer scientific, industrial and service magazine in the environmental field, is **independently published** in January, April, July and October by Environmental Publications, Inc., Martin Z. Post, editor and pulisher. Quarterly welcomes all competent expressions of opinion, but statements in its pages do not necessarily reflect its views. **Editorial and business address: P. O. Box 2583, Grand Central Station, New York 17, N. Y. Telephone: BA 5-0880.** Subscription: $4 annually in the U. S. and Canada; $5 elsewhere. $1 per copy. With the expiration of the current subscription period, Quarterly will be circulated free of charge to individual scientists, engineers, educators, students, and others in the U. S. who have a professional or business interest in environmental research, simulation and testing. The rate to all others will remain the same. Printed by Princeton Printing Co., Princeton, N. J.

Copyright © Environmental Publications, Inc., 1959.

HOW GUARDITE CUTS COSTS OF ENVIRONMENTAL TESTING

29,000 HRS. CONTINUOUS OPERATION WITHOUT DOWN TIME is the record of this complete environmental laboratory installation.

Superb Engineering, Precision Construction, Keep Maintenance Expense at Record Low

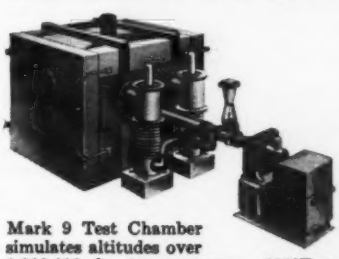
Too often the lowest bid ends up as the *highest overall cost*—when down time and excessive maintenance expense are added.

Guardite bids on Environmental Test Equipment are always sharp-pencilled—but never at the sacrifice of performance and durability. The most significant savings show up in trouble-free operation, year after year. Guardite's exceptional record of low maintenance and high performance applies to a very wide field of test equipment, from 3 cu. ft. chambers to huge installations that explore new frontiers of hyper-environmental research.

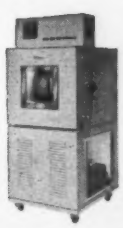
We are equipped to accept your toughest problems on a design-study basis—or we will do all engineering, fabricating and testing from your performance specifications. Write or phone for information—*and be sure to get the new Guardite Catalog.*

From 3 Cu. Ft. Chambers to Mammoth Testing Installations

Guardite Chamber for research and development with special military equipment



Mark 9 Test Chamber simulates altitudes over 1,000,000 ft., temperatures −100°F to 1000°F.



High-Low Temperature Trop-Arctic Chamber −100°F to 250°F, 3 cu. ft. capacity (Available from stock)

Write for complete new catalog to Guardite Company, Dept. EQ, Wheeling, Illinois

GUARDITE
DIVISION OF
AMERICAN-MARIETTA COMPANY

AROUND THE ENVIRONS...

Chicago Equation:

IEE + SEE = IES

The long-sought merger of the two big scientific/technical societies in the environmental field took place this Spring in Chicago. The new group is the Institute of Environmental Sciences, and its first president is Harold C. Jones, of the University of Maryland.

The merger brought together the 500-member Institute of Environmental Engineers, which dated back—originally as the science section of the Environmental Equipment Institute—to 1954, and the 200-member Society of Environmental Engineers, formed in California in 1956. Announcement that the two groups had gotten together was made by Roger J. Amorosi as the IEE's third annual meeting drew to a close. (See Pages 19 and 22 for photo album of the meeting.) Amorosi, head of Long Island's Parameters, Inc., retired as IEE president, while Leon D. Carver, of High Accuracy Products Corp., stepped down as SEE chairman.

Vandal

Billet

Jones moved up to the presidency of the IES after a term as executive vice president of the IEE, of which he was a founder. He is an electrical engineering graduate of the Illinois Institute of Technology.

Serving with him on the IES executive committee are:

William L. Vandal, executive vice president; Arthur B. Billet, vice president, fiscal affairs; Russell Lowe, vice president, membership; Carver, vice president, local chapters, and Raymond Yaeger, vice president, publications. Henry F. Sander is executive secretary, and Amorosi is ex-officio member of the committee.

Amorosi

Vandal, engineering group leader of the environmental lab at Autonetics, a division of North American Aviation, Inc., will also serve as program chairman of the first IES annual technical meeting and equipment show, slated for the Biltmore Hotel, Los Angeles, April 6-8. A charter member of both the IEE and SEE, his new post puts him in line for the IES presidency next year, if old IEE custom holds true.

Vandal is a graduate of New York State Teachers College. A recognized authority in dynamics and atmospherics, he came to North American via the Air Force, Navy and Engineering Research Associates. He is a Navy reserve lieutenant and an avid sports car fan, and, with his wife and three children, lives in Garden Grove, Calif.

Sander

Billet, who is in the new society's financial hot seat, is a specialist in aircraft hydraulics and has written extensively on the subject. Since World War II, in which he served as an Air Force pilot, he has been with Vickers Incorporated, Detroit, the past 3½ years as senior staff engineer of the Aero Hydraulics Division. An aeronautical engineering graduate of the University of Michigan, Billet was an IEE vice president since 1957 and is president of the IES's Detroit chapter. He was general chairman of the Chicago convention.

Lowe, the membership chairman, is with Barry Controls, Watertown, Mass. Yaeger is with the Chrysler Missiles Division, Warren, Mich., and served as facilities chairman for the recent convention. Sander is chief test engineer at Vapor Heating Corp., Chicago.

Learning to Improve Environments

The Rucker Company, Oakland, Calif., and MB Electronics, Inc., New Haven, Conn. have undertaken environmental educations projects.

Rucker invited a group of Aerojet-General and Lockheed Missile and Space division engineers to a one-day, first annual symposium "to promote a free exchange of ideas regarding the qualifications of a modern test stand as applied to the testing of hydraulic missile components."

The consensus: a highly successful meeting. Those who attended are pictured above. Standing (left to right) are: A. Krueger, Rucker; Richard G. Erickson, Aerojet; J. M. Ayers, Rucker; R. Bernardo, H. T. Sagray and H. W. Stoel, Lockheed.

Seated (left to right) are: William [illegible]nett, E. N. Goddard, R. Cochrane and E. Thompson, Lockheed; R. Lenheim, Edwards and A. E. Kremiller, Rucker, David Youre, Z. H. Chapman and Famanian, Lockheed.

MB has scheduled a series of two-week training seminars on complex vibration testing monthly through November. They are being conducted by Dr. Theron Bisher, of Yale University, a consultant in vibration and acoustics.

Wayne Tustin, MB preliminary design engineer, is coordinating the program for MB. Tuition and fees total $300. (*For more info circle EQ RSC #30.*)

Better Than People

The Massachusetts Institute of Technology Instrumentation Laboratory subjected the guidance system of a ballistic missile to rock 'n' roll. The music was amplified almost beyond recognition into a vibrator.

The guidance system passed the shake test with flying colors, M.I.T. reported. There was no word as to how the lab staff fared.

Vacuum, Electronics Meeting

The American Vacuum Society's [illegible] national symposium on vacuum technology will be held Oct. 7-9, 1959, at the Sheraton Hotel, Philadelphia. "A High Vacuum—High—Low Temperature Environmental Chamber" will be discussed by B. J. Reitzer, R. B. Blaski and W. Gates, of the Guardite Company, Wheeling, Ill.

The 15th National Electronics Conference will meet Oct. 12-14, 1959, at the Sherman Hotel, Chicago. An attendance of 10,000 is expected.

EXCELLENT OPPORTUNITY

FOR DESIGN ENGINEER IN THE FIELD OF

ENVIRONMENTAL TEST EQUIPMENT MFG.

WITH LEADING FAST GROWING EAST COAST CORP.

Environmental Quarterly Desk "C"

ALL RESUMES CONFIDENTIAL

Defense Department Revises Electronic Parts Environmental Requirements Guide

The Defense Department has revised and updated its "Environmental Requirements Guide for Electronic Component Parts," first published in 1957. The new, 13-page volume, MIL-HDBK 131423R, is available through the Department of Commerce's Office of Technical Services at 50 cents a copy.

The guide gives R & D environmental design requirements for current and future electronics planning and reviews appropriate test procedures.

Components dealt with include such basic circuit elements as capacitors, resistors, switches, relays, transformers, crystals, waveguides, electron tubes and semiconductor devices. They are divided into application groups covering use in shipboard and ground components, high-performance and nuclear powered aircraft, and nuclear-powered weapons and missiles.

THERMOSEAL

. . . viewing glass units for environmental chambers. Tolerates —100° to +350° F differential. Prompt deliveries.

. . . *tempered glass units and tempered glass now available for rapid delivery.*

We also offer engineering service.

THERMOSEAL GLASS CORPORATION

P.O. Box 342 • Camden, N. J.

ENVIRONMENTAL TESTING

AT THE

"CROSS-ROADS OF THE NATION"

An independent testing laboratory with complete facilities for testing your products to requirements of Government and Industrial Specifications.

- Vibration
- Acceleration
- Temp. Altitude
- High Temperature
- Low Temperature
- Temperature Shock
- Humidity
- Salt Spray
- Sand & Dust
- Mechanical Shock
- Fungus Resistance
- Radio Interference

LAMBERT ENGINEERING COMPANY

Research & Testing Laboratory

1100 Macklind Ave. St. Louis 10, Mo.

Phone: MIssion 7-3488

HARRIS 2-CHAMBER UNIT GIVES DOUBLE TEST CAPACITY— HIGH OR LOW TEMPERATURE OR BOTH

Harris ingenuity, traditional since 1934, is exemplified in this double chamber environmental testing unit. The two chambers are completely separate and independently controlled, though chilled by a single refrigeration machine. Both provide complete temperature range from —125° F. to +250° F. Both may be operated simultaneously at either temperature extreme, or one may be set for low temperature and the other for high temperature testing. This exceptional versatility at least doubles the unit's capacity since two separate tests may be run at the same time. In use by several major electronic manufacturers, it has proved dependable, effective, and highly economical for production testing.

SPECIFICATIONS: Outside dimensions — 74" long x 36" deep x 76" high. Net free working area in each chamber — 24" x 24" x 24" (8 cu. ft.). Temperature range: —125° F. to +250° F.

Harris Model 2-8EL-AU2 2-chamber hi-lo temperature testing unit

HARRIS REFRIGERATION CO.

312 RIVER ST.

CAMBRIDGE 39, MASS.

Environmental testing equipment for every requirement, standard or custom models. Write for our advice. There's no obligation.

The Seismic Shock and Vibration Pickup

by JOHN H. ARMSTRONG
and GEORGE STATHOPOULOS
Naval Ordnance Laboratory
White Oak, Md.

Study of vibratory or shock motion of a point by direct comparison of its position with respect to a stationary reference is generally practical only under laboratory conditions, and then only for oscillatory or short-duration disturbances. Hence, the bulk of shock and vibration instrumentation is based on seismic pickups.

In the seismic pickup shown schematically in Fig. 1, a mass m, supported upon an elastic element of stiffness (spring constant) k, is guided to move along the sensitive axis within a rigid case attached at the point whose motion is to be studied. When the case is moved there is relative motion between the seismic mass and the case which is sensed by suitable mechanical or electrical means. From this relative displacement y or velocity $\dot{y}$, the exciting motion x can be deduced by the application of well-understood and generally tractable equations.

The pickup thus carries within itself an inertial reference and does not require any contact with a stationary zero-point; transient accelerations of indefinitely long duration can be measured with a compact instrument.

There are two principal limitations: The pickup must be accelerated by the element upon which it is mounted, so its use is restricted to measuring the motion of relatively massive members, and it can measure accurately only components of motion within certain frequency limits.

These limits are determined partially by the nature of the idealized seismic system and by the degree to which a practical instrument can approximate the theoretical system. (Editor's Note: The latter aspect will be discussed in a second article to be published in the October issue of *Environmental Quarterly.*)

The Idealized Seismic System

In the generalized system, there is also an element producing a viscous damping force $c\dot{y}$ proportional to and opposite in sign to the relative velocity of case and mass. Spring and damper are assumed to be weightless and there is no dry or Coulomb friction (not proportional to velocity) in the system.

If the case is subjected to motion such that the instantaneous position of the pickup case with respect to an inertial reference is x, the differential equation governing the system may be obtained by equating all forces acting upon the mass to zero. The position of the mass with respect to the inertial reference is $y-x$ and the equation is: $m(\ddot{y}-\ddot{x}) + cy + ky = 0$, and, rearranging terms,

$$\ddot{y} + \frac{c\dot{y}}{m} + \frac{ky}{m} = \ddot{x}$$

(Equation 1)

The significance of this relationship, which completely describes the performance of the idealized instrument, is most easily studied by imposing a sinusoidal or simple harmonic displacement $x \cos \omega t$ upon the case, where ω, equal to $2\pi f$, is the circular frequency of the excitation in radians per second. This motion is a typical input for much steady-state vibration measurement work and, as will be discussed later, is of some use in estimating the response of an instrument to transient motions.

Natural Frequency

The ratio of the resulting amplitude of motion of the mass with respect to the case – the output signal from the instrument – to the input displacement, obtained by solving Equation 1, is:

$$\frac{Y}{X} = \frac{\omega^2}{\left[\left(\frac{k}{m} - \omega^2\right)^2 + \left(\frac{\omega c}{m}\right)^2\right]^{1/2}}$$

(Equation 2)

If damping is zero, Y will become infinite and resonance will occur when $\omega^2 = k/m$ and the denominator becomes equal to zero. This is the *natural frequency* of the instrument, designated ω_n, or f_n when in terms of cycles:

$$\omega_n = \left(\frac{k}{m}\right)^{1/2} \qquad f_n = \frac{1}{2\pi}\left(\frac{k}{m}\right)^{1/2}$$

(Equation 3) (Equation 4)

The term ω_n is often referred to as the *undamped* natural frequency to distinguish it from the *resonant*

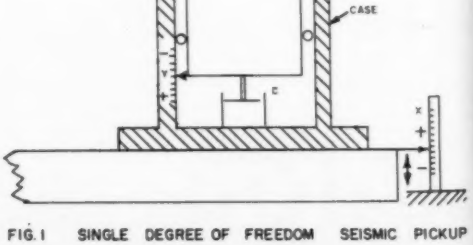


FIG. 1 SINGLE DEGREE OF FREEDOM SEISMIC PICKUP

damped natural frequency observable in calibrations of practical instruments with damping. For the analysis of instrument performance, with or without damping, the undamped frequency is the characteristic most clearly determining its performance in measuring motions of a given frequency.

As these equations indicate, the natural frequency is proportional to the square root of the ratio of the stiffness of the elastic element to the mass it supports. For visualizing the situation, a convenient measure of this stiffness is the static deflection δ_{st} of the system under gravity, which is equal to mg/k. Making the substitution in Equation 3 and 4, δ_{st} in inches:

$$\omega_n = \frac{19.6}{\delta_{st}^{1/2}} \qquad f_n = \frac{3.13}{\delta_{st}^{1/2}}$$

(Equation 5) (Equation 6)

Seismic pickups intended for use as velocity or displacement meters must have a natural frequency lower than the frequency of components of motion to be measured, whereas accelerometers must have a natural frequency high with respect to measured frequencies. The soft suspension of the velocity pickup therefore has a large static deflection; for a natural frequency of 1 cps, for example, δ_{st} is approximately 10 inches. Such instruments are necessarily bulky and may require adjustment when changing orientation with respect to gravity.

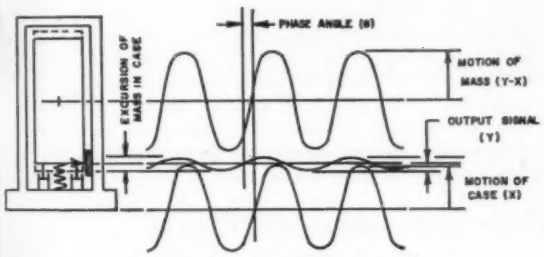


FIG. 2 MOTION OF ACCELEROMETER ELEMENTS

(Under steady-state sinusoidal excitation at a frequency of .4fn. Damping is .7 critical; acceleration amplitude ratio, .98; phase lag, 36°. Note that motion of mass with respect to case is about one-sixth the amplitude of the exciting motion.)

The accelerometer, on the other hand, will have a stiff suspension if it is to be usable at frequencies of interest in most shock and vibration measurements, and many of its practical design problems stem from the resulting requirement for sensing and damping means that will develop the needed output and force with extremely small displacement.

Damping

For convenience, the damping term in the equations governing system behavior is usually expressed as the *damping ratio*, the ratio of the actual damping coefficient c to the *critical damping coefficient*, c_c. The critical damping coefficient is the minimum damping that will cause a displaced elastic system to return to its equilibrium position without oscillation. For the system considered here, in the absence of external excitation (described by Equation 1 with right-hand term set equal to zero):

$$c_c = 2\,(km)^{1/2}$$

(Equation 7)

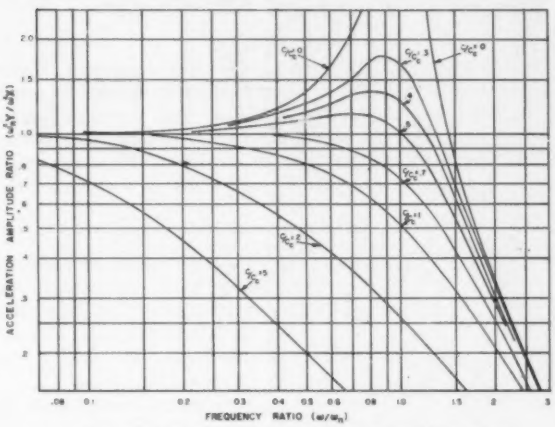


FIG. 3 RESPONSE OF AN IDEALIZED LINEAR ACCELERATION PICKUP

It is now possible to study, in dimensionless terms, the response of practical seismic instruments to sinusoidal inputs. The acceleration of the case *a* under the assumed sinusoidal exciting motion $X \cos \omega t$ is equal to $-\omega^2 X \cos \omega t$. Under this excitation the seismic mass will be accelerated by the elastic element in accordance with the Newtonian relationship $F = ma$. If the sensing element – a strain gage or differential transformer, for example – indicates the mass-case displacement *y*, which is equal to F/k or ma/k, the indication of a seismic instrument functioning as an accelerometer is therefore:

$$a = \frac{ky}{m} = \omega_n^2 y$$

(Equation 8)

The ratio between the acceleration indicated and that of the exciting motion, determined by the solution of Equation 1 is then:

$$\frac{^2Y_n}{^2X} = \frac{1}{\left[\left(1 - \frac{\omega^2}{\omega_n^2}\right)^2 + \left(\frac{c\omega}{c_c\omega_n}\right)^2\right]^{1/2}}$$

(Equation 9)

Figure 2 depicts the situation: The mass follows the motion of the case with a relatively small phase lag (less than 90°), and mass-case displacement *y* is small with

(Continued on Page 8)

Armstrong

Stathopoulos

John Armstrong and George Stathopoulos are veteran members of the staff of the Naval Ordnance Laboratory at White Oak. Armstrong has been there since 1943, Stathopoulos since 1945. A Purdue mechanical engineering graduate, Armstrong is chief of the NOL Air and Surface Mechanical Engineering Department. He was a Navy member of the Interservice Coordinating Committee for Shock and Vibration in its early years and has been working on equipment for simulating the environment of naval ordnance. Stathopoulos, a graduate of Villanova in electrical engineering, is staff consultant in the NOL Environment Simulation Division. He has been concerned with evaluating the performance of experimental ordnance designs under shock and vibration.

Seismic Pickups

(Cont'd from Page 7)

respect to the displacement of the exciting motion. Figure 3, a graphic presentation of Equation 9, shows the effect of damping and frequency ratios upon the acceleration amplitude ratio. The instrument measures acceleration accurately (as indicated by an amplitude ratio near unity) over a range of frequencies *below* its natural frequency.

Velocity/Displacement-Meter Response

Figure 4 illustrates the relative motions of case and mass for a lightly-damped system when the exciting frequency is well *above* the natural frequency. In this case, typical of displacement-meter operation, the mass remains essentially stationary in space while the case moves about it. The relative motion y between mass and case is out of phase with the exciting motion and is approximately equal to it in amplitude.

For a seismic instrument sensing the relative displacement between case and mass, the amplitude of the instrument output Y is related to the input displacement amplitude X as follows:

$$\frac{Y}{X} = \left(\frac{\omega}{\omega_n}\right)^2 \frac{1}{\left[\left(1 - \frac{\omega^2}{\omega_n^2}\right)^2 + 4\left(\frac{c}{c_c}\right)^2\left(\frac{\omega}{\omega_n}\right)^2\right]^{1/2}}$$

(Equation 10)

This amplification factor Y/X is the measure of the accuracy of the system in functioning as a true displacement pickup; it is plotted in Figure 5.

The amplitude of the case X and mass-case Y motions being essentially equal in magnitude when the system is functioning in this manner, the peak instantaneous velocity between mass and case $Y\omega$ is also equal to that of the exciting motion $X\omega$. Therefore, the instrument is equally suitable as a velocity meter if its sensing system (a moving coil in a magnetic field, for example) responds to mass-case velocity rather than displacement.

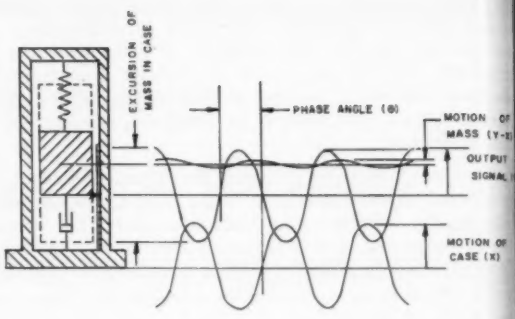


FIG. 4 MOTION OF DISPLACEMENT OR VELOCITY PICKUP ELEMENTS

(Under steady-state sinusoidal excitation at a frequency of above 3.0fn. Damping is .15 critical; displacement (or velocity) amplitude ratio, 1.12; phase lag, 174°.

Distortion in Pickups

The measure of the usability of a pickup is its ability to translate motion into a signal which is a satisfactory undistorted representation of the input.

If the calibration factor varies with the frequency of the exciting motion, within the range of measurement, *frequency distortion* is present. The principal cause of this form of distortion is the presence of components of motion outside the frequency range over which the seismic system functions as a true velocity/displacement pickup or accelerometer. As Figures 3 and 5 indicate, for steady-state excitation of an idealized system, natural frequency and damping uniquely determine the extent of frequency distortion from this cause. These characteristics are therefore usually specified in stating concisely the usable range of a pickup.

If components of the exciting motion of different frequencies do not appear in the same time relationship in the output signal, *phase distortion* is present. In vibration measurement, this is usually unimportant. In the study of shock motions, however, the phase relationship may be an important factor in the practical significance of the disturbance and such distortion must also be minimized.

(Continued on Page 1

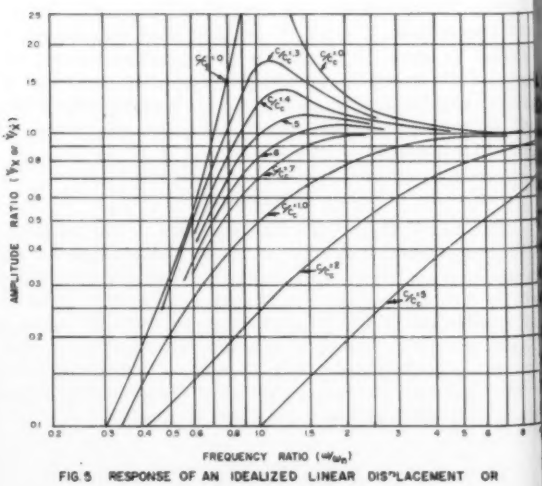


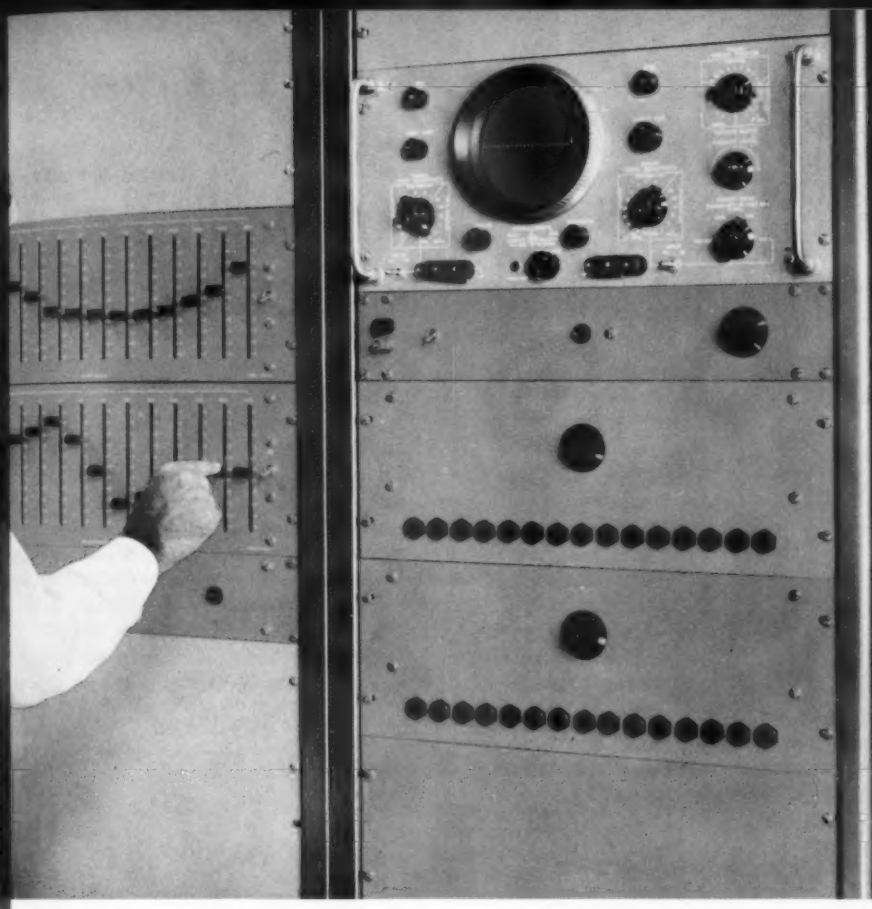
FIG. 5 RESPONSE OF AN IDEALIZED LINEAR DISPLACEMENT OR VELOCITY PICKUP

OPERATIONAL TESTING under all ENVIRONMENTS

Use our facilities to evaluate product operation under all environmental conditions. Get automatic alternating cycles of contrasting conditions... remote control of product operation by mechanical, electrical or hydraulic means... and a wide range of supply voltages and frequencies. Simulate high-low temperatures, humidity, altitude, explosion, immersion, salt spray, sand and dust, rain, fungus, vibration, shock, acceleration, etc. Test to military, government and commercial specifications.

Complete facilities in the fields of chemistry; metals chemistry; metallurgy; physical testing of materials; engineering analysis of mechanical, electromechanical and electronic devices; site inspection; package testing; psychometrics and certification services for product quality control.

UNITED STATES TESTING COMPANY, INC.
1515 Park Avenue, Hoboken, N. J.
Branch Laboratories:
BOSTON • BROWNSVILLE • DALLAS • DENVER • LOS ANGELES
MEMPHIS • NEW YORK • PHILADELPHIA • PROVIDENCE • TULSA



ESD-20
Spectral Density Equalizer
(left panel)
allows rapid, accurate equalization of vibration and high-intensity sound systems for random testing. Adjustments can be made during testing at any vibration level.

ASD-20
Spectral Density Analyzer
(right panel)
generates a continuous power spectral density plot of a random wave vibration signal for display on a cathode ray oscilloscope.

ing announces a major breakthrough in random wave equalization and control

New Spectral Density Equalizer/Analyzer System

for continuous and parallel observation and control of test spectrum in vibration and acoustic testing programs

nouncing another Ling first—the new Spectral Density ualizer/Analyzer System! This new system allows *continuous, rallel* observation and control of the entire spectrum of energy stribution during random wave vibration or high-intensity und testing.

e Ling ESD-20/ASD-20 System reduces peak and notch filter -ups... eliminates tedious adjustments for system response iformity... makes continuous, accurate equalization possible any vibration level.

the Ling Spectral Density System, the random source output divided into 26 frequency bands—each independently controlled a simple vertical attenuator. Outputs from all 26 bands are pidly and sequentially sampled and displayed on a cathode ray cilloscope to provide the operator with a continuous view of e spectrum during the test. This new equalization system may added to existing random wave vibration test systems... or corporated in any new Ling random wave system. Available y from Ling Electronics.

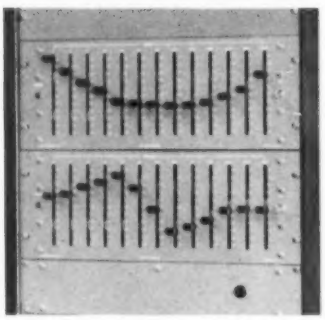
5 Major advantages of new Ling ESD-20/ASD-20 System

1. **FASTER**—Reduces set-up time to a few minutes.
2. **MORE ACCURATE**—Permits continuous, parallel observation and control of entire spectrum. Load shifts during test can be detected and corrected immediately.
3. **BETTER EQUALIZATION**—Compensates amplitude non-linearities in specimen or system components.
4. **EASIER TO OPERATE**—Operator has continuous picture of shaker vibration spectrum on oscilloscope ... makes corrections with simple level adjustments of filter attenuators.
5. **BETTER SPECIMEN PROTECTION**—New Ling system prevents over stress of specimen during set-up stages.

LING ELECTRONICS, INC.

Additional details on reverse side

The new LING method of equalization in random wave vibration and acoustic testin



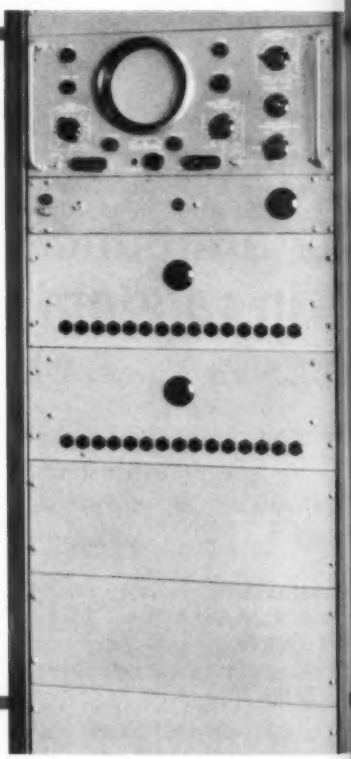
ESD-20 SPECTRAL DENSITY EQUALIZER

The Ling Spectral Density Equalizer consists, essentially, of 26 sharp cutoff bandpass filters that are driven from a common source. The filters, with external shaker equalizer, cover the 10-2000 cps frequency range and separate the input test signal into 26 narrow frequency bands. The signal output level of each filter is continuously adjustable over a full 60 db range by means of vertical linear motion attenuators. By individually adjusting the filter outputs, the spectrum of the input signal can be shaped to compensate for any undesirable transfer characteristics in the system components or the specimen being tested. Very high Q load resonances are not compensated because random energy in these regions is very small.

ASD-20 SPECTRAL DENSITY ANALYZER

The Ling Spectral Density Analyzer includes 30 sharp cutoff bandpass filters, all driven from a common source. Twenty-six of the filters duplicate the frequency range of the ESD-20 Equalizer. The other four filters serve as indicators for the spectrum from 10-70 and above 2000 cps. The input vibration acceleration signal is separated by the filters into narrow frequency bands. Each filter ouput signal is averaged, squared and applied to a high speed switch. The switched outputs produce vertical deflections proportional to the average power spectral density over the bandwidth of each filter. These outputs are displayed on a cathode ray oscilloscope as a series of dots forming the continuous spectral density plot.

Operating as a System, the ESD-20 Equalizer and ASD-20 Analyzer provide the operator a continuous picture of the shaker acceleration output. Necessary corrections in energy distribution can be made immediately at the Equalizer by means of simple level adjustments of the filter attenuators. Mixed sine-random wave testing can be easily accomplished by the use of the Ling S-11-D1 or S-14 Servo Systems in conjunction with the ESD-20 Equalizer.



New Spectral Density Equalizer/Analyzer System displays a *continuous* analysis of acceleration distribution versus frequency during testing... and allows rapid control of the spectrum for corrections in energy distribution.

LING ELECTRONICS, INC.

For additional information, write or call...

Factory Sales Offices:
9937 West Jefferson Blvd., Culver City, California—TExas 0-7711
120 Cross Street, Winchester, Massachusetts—WInchester 6-3810

Seismic Pickups (Cont'd from Page 8)

Figure 6 presents the phase lag θ in terms of frequency and damping ratios in the idealized system. If there is no phase lag, (as in the case of an undamped pickup operating at less than its natural frequency) or if all frequencies of interest are displaced by a phase angle which is proportional to the frequency, the various components of motion will appear in the same relationship to each other and there will be no phase distortion. The second condition is approximated in an accelerometer with .7 critical damping.

Optimized Pickup Characteristics

An accelerometer should have a natural frequency as far above that of the highest frequency component of motion to be measured as is possible within the limits of acceptable sensitivity and practical construction. The usable frequency range will of course depend upon the extent to which distortion is allowable. If 5 per cent distortion of the highest-frequency components is acceptable, an undamped pickup may be used to measure steady-state motions up to .22 of its natural frequency, and there will be no phase distortion.

If damping equal to .7 critical is provided, the 5 per cent limit is extended to approximately .6 f_n. Phase distortion considerations also indicate that this value of damping is optimum, phase lag being most nearly linear with frequency at this value.

Since damping also reduces or eliminates the large amplification values for components of motion in the vicinity of f_n, it is usual practice to introduce damping in this range into accelerometers unless the natural frequency can be made very high. If this is the case, a lower damping ratio may be selected because of other practical considerations, such as reduction in performance variation with temperature change.

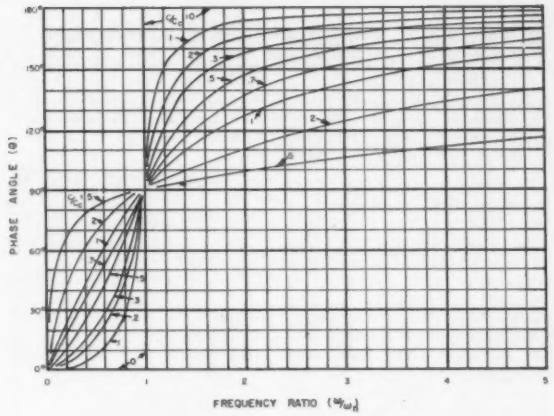


FIG. 6 PHASE RESPONSE OF AN IDEALIZED LINEAR PICKUP

The natural frequency for velocity or displacement pickups should be as far below that of the lowest frequency component being measured as possible within space and stability limitations (see Figure 5). At the 5 per cent distortion level an undamped pickup is usable only at frequencies above approximately 4.5 times f_n. If .65 critical damping is provided, this ratio is reduced to 1.4.

As Figure 6 indicates, however, there will be a great deal of phase distortion since there is no value of damping which will provide phase shift linear with frequency over

(Continued on Page 30)

WING VIBRATION

New daylight 701 measures amplitude of displacement of selected points on a missile wing. Small right angle targets of .020" aluminum foil ⅛" x ⅛" are glued at each intersection of grid lines. Hard industrial wax gunked at back of target to deaden flutter of target itself.

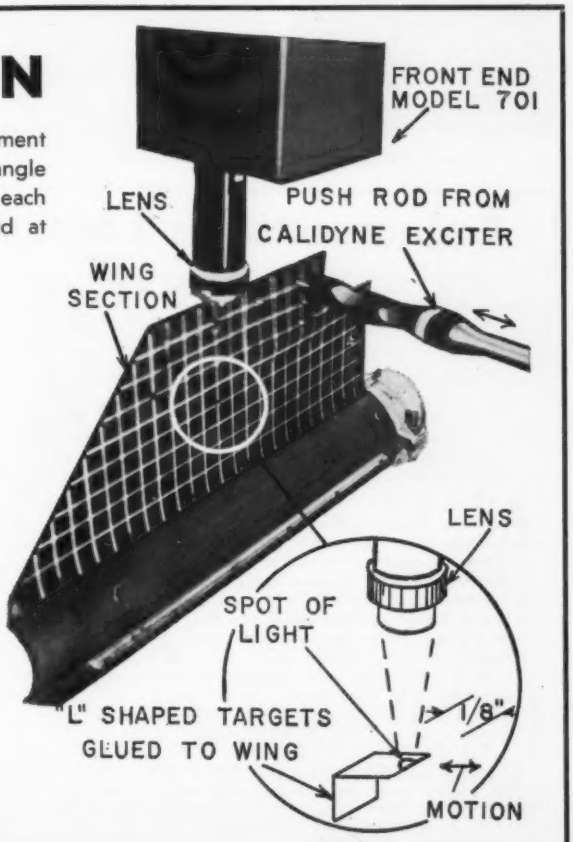
Spot of light is focused on top edge of target. Wing is driven with horizontal push rod from Calidyne exciter. Vibration measured is perpendicular to wing surface. Instrument may be scanned from point to point without stopping exciter.

Measurements accurate to .001" may be made at a working distance of 56" from lens. Five other interchangeable lenses cover displacement ranges of .050", .100", .500", 1.0", & 2.0" full scale. Best resolution 12 micro inches. Frequency response static to 7 Kc. Output 16 volts full scale, 250 ohms.

See it at WESCON, Booth 3702.

OPTRON
CORPORATION

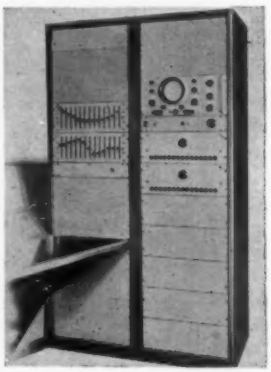
335 So. Salinas • Santa Barbara, Calif.



NEW PRODUCTS...

A "Reader Service Card" requiring no postage is bound into this issue for the convenience of those desiring additional information on new products, new literature (Page 32) and other announcements. It is keyed in the text as "EQ RSC.")

New random wave equalizing system by Ling Electronics, Inc., consisting of spectral density equalizer and spectral density analyzer, provides continuous analysis and control of shaker acceleration output, frequency by frequency. Corrections in energy distribution can be made immediately by means of simple level adjustments of filter attenuators. Model **ESD-20 equalizing system** divides the spectrum of random or complex vibration signals into 26 separate frequency bands, each independently adjustable in amplitude at any vibration level. **Model ASD-20 analyzing system** analyzes average acceleration power spectral density of 30 separate frequency bands in the output response of vibration



test system. An electronic switch sequentially gates each of 30 power spectral density channels for display on a cathode ray oscilloscope.

For More Information Circle EQ RSC #1

* * * *

Hydraulic vibration system incorporated into one end of

the **Genisco, Incorporated, F325 centrifuge** boom develops 1,200 force-pounds. The system is capable of an excursion up to ½" double amplitude and an acceleration level up to 20 Gs over a frequency range of from 5 to 500 cps. Mounting platform supports a 12" cube weighing 40 lbs. Maximum centrifugal capacity of the F325 is 5,000 G pounds.

For More Information Circle EQ RSC #2

Environmental Want Ads

EQ's classified advertising section will appear in this space beginning with this (July '59) quarterly. For further information see "Post Scripts" on Page 2 of this issue and write "Environmental Want Ads," Environmental Quarterly, P. O. Box 2583, Grand Central Station, New York 17, N. Y. Classified advertising information will not be given by telephone.

Rates: $3 (minimum) for three 8-point lines, $2 per line additional "Situation Wanted" ads will be published without charge to those who can reasonably expect to find employment in the environmental industry, if they follow the form prescribed below. First three lines free for those who prefer to write their own "Situation Wanted" ads. Deadline for October issue Want Ads is Sept. 10.

For a free "Situation Wanted" ad give:

- **Specialty (two permitted), such as mechanical engineer, purchasing agent, sales engineer, etc.**
- **Age (if you want to give it).**
- **Degrees beyond bachelor's.**
- **Recent experience and salary desired.**
- **Where you prefer to work (New York, West coast, etc.).**
- **Name and home address (or an EQ code number, if you wish, but you must give name, home address and present employment in letter requesting ad.)**

HELP WANTED

JR. E. E. for missile R & D Center. Work is environ'l eval. of elect. gear. Stress on instrumentation. Address Code 5516 NOTS China Lake, Cal.

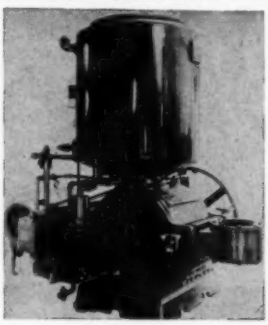
Tenney-mite STRAT by Tenney Engineering, Inc., takes up only four square feet of floor space but provides 14-inch cube of testing space at up to 200,000' alt. and from —100° to +350° F. Pull-down rate is from ambient to —100° F in about one hour. Heat-up from ambient to maximum takes about one-half hour. Vacuum system simulates 100,000' (8.02 mm. Hg. Abs.) in 12 min., 150,000' (1.128 mm. Hg. Abs.) in 20 min. and ultimate range (.2560 mm. Hg. Abs.) in an hour. Can be mounted on casters.

Patented cascade unit u Freon 13 and 22. Powe from 200v outlet with a p -in cord.

For More Information Circle EQ RSC #3

* * * *

High vacuum pump, 1,100 cfm capacity, has been add-



ed to **Beach-Russ Co.'s T RP** "rotary piston" l The new pump, **Model 1** is available in dry, va purge and two-stage sions. Like the rest of RP line, Model 1000 wo on direct, positive rot motion, which makes very quiet operation fre excessive vibration. Eff ency is claimed at a v high level over entire pu ing range. Requires only hp. motor. Said to be es ially suited for large s tems handled by mechan pumps only and on a matic machinery.

For More Information Circle EQ RSC #4

* * * *

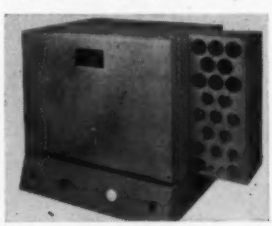
Automatic ozone control system, Model OREC 0300-3, by Ozone Research & Equipment Corp. with unique input meter directly calibrated in pphm/volume is said to be the first such system ever available. Operates by means of electronic-chemical loop feed back servo system. Multiple ozone concentration ranges from 0-25 pphm volume to in excess of 0-10% volume. Accuracy 4% of operating scale. Sensitivity less than 1 pphm/volume. Standard bench unit is 23x19½x15", weighs 115 lbs., uses 110-

115v 60 cycle AC. For l and industrial process manually controlled ozo test chambers and alt, te and hum environment chambers.

For More Information Circle EQ RSC #5

* * * *

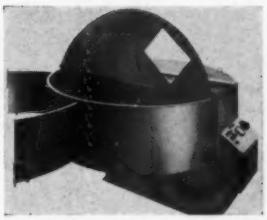
Dual-purpose CECO chamber from Heat Systems Co. permits testing diodes, capacitors, transistors, resistors and similar compon-



ents under heat or co while under electrical lo Automatic or manu switches place each co ponent in turn across measuring bridge or a other circuit during a te erature run or load life t Liquid CO2 or mechani refrigeration for co shocks or testing in sa chamber. Standard sizes f both pilot and producti testing. Oven has a cyclin error of ±2° F and a ca brated control.

For More Information Circle EQ RSC #6

Electronic control circuit, exclusive on its **Models RCT1** and **RCT2** centrifuge acceleration test machines, is announced by **The Rucker Company** for electronic programming, sequencing and remote operation with infinite G loading variations. Only one digital setting is required to establish desired speed range. Shown is Model RCT 2, with simulated acceleration rating to 150 G, 46-inch test radius and specimen capacity to 150 lbs. Rucker standard units are

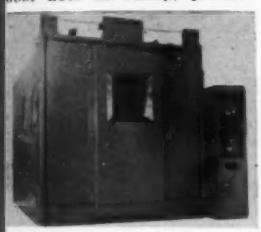


available with test radii from 18" to 35', test load capacities of up to 9,000 lbs. and with accessories for testing in any environmental combination.

For More Information Circle EQ RSC #7

• • • •

Walk-in chamber, Model WD-420, by **Conrad, Inc.,** has environmental options and power operated, full opening front door that recesses below floor. Top of door acts as ramp, permitting flush chamber and building floors. Available temp capability from —100° to +500° F. Refrigeration from patented Freon 13-22 cascade system. Humidity control equipment can be furnished with available range 20% to 98% from 35° F. dew point to +185° F. Rainfall available on special order to simulate 1" or 4" per hour. Pictured electronic potentiometer type programming recording controllers, operating from copper constantan thermocouple, are one of several instrumentation options.



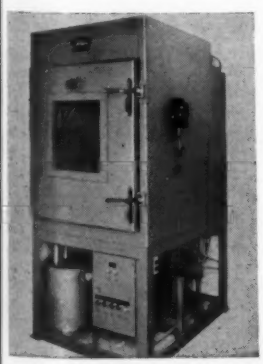
For More Information Circle EQ RSC #8

• • • •

Low cost temperature chamber for mil-spec testing, hot or cold treatment of metals, production processing and temp stabilization work has been placed on the market by **Missimers Incorporated.** Temp range from —100° to +350° F. Manufacturer claims accuracies are controlled to ±3° F over full temp range. The unit, **Model FT1-100X-350,** has cascade refrigeration and a special heating system, working space of one cubic foot and outside dimensions of 35x24x45". Construction is said to be of same type and quality as larger, more expensive units, with stainless steel inner liner welded to form vapor barrier.

For More Information Circle EQ RSC #9

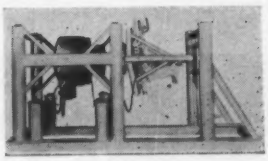
• • • •



Rain and sunshine test chamber for current MIL-E-5272A and related testing has been developed by **Standard Cabinet Co. Model RS/18 FS** has 30x30x36" inside test space, **Model RS-/36 FS** has 36x36x48". Full front opening door with 16x 18" window. Instrumentation includes an indicating temperature controller. Pyrheliometer to measure total radiation available as extra. Chamber simulates vertical rainfall in small droplets at rate and temps required.

For More Information Circle EQ RSC #10

Auxiliary vibration test fixture, by MB Electronics, Inc., is available in two sizes to accommodate MB vibration exciters C25H and C10. The fixture, called **Tri-Mode,** is of welded tubular steel construction. Larger unit handles specimens up to 44 x 66" without height restriction. Suitable hot-cold or alt chamber can be



mounted on the fixture for limited environmental testing.

For More Information Circle EQ RSC #11

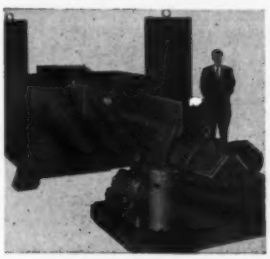
• • • •

Acton Laboratories Incorporated, has introduced a new version of its **Type 310-B Z-Angle** meter, featuring direct readings of impedance, phase angle, dissipation factor and storage coefficient. Frequency range is 30 cps to 40 kc. There are internal 60 and 400 cps test signals. Impedances are measured directly in the polar form $Z/\pm O$ (or, magnitude in ohms and phase angle in degrees). The meter is simple to operate as only one balancing step is required. It is compact and portable. Uses include measurements of amplifiers, electro-acoustic transducers, transmission lines, filters, indicating meters and transformers.

For More Information Circle EQ RSC #12

• • • •

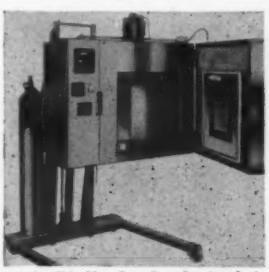
Reaction vibration machine system by L. A. B. Corporation vibrates loads up to 10,000 lbs. in both vertical and horizontal directions but requires no special foundation to absorb reactive forces. Believed to be the biggest of its kind ever produced. **Type RVH-96-10,-000** operates in a frequency range from 5 to 60 cps with adjustable displacement from 0 to .125" max. Changes in direction of vibration and displacement settings can be made in minutes with load in position. Maximum acceleration rating is 10G. A torque bar system of table suspension prevents generated vibrations from being transmitted to the floor, even though maximum force output exceeds 300,000 lbs. so that the machine can be made mobile. Table size is 8x8' and loads require no external support.



For More Information Circle EQ RSC #13

• • • •

Liquid CO2 high-low temperature test chamber by **Harris Refrigeration Co.** is designed for use with both horizontal and vertical vibration exciters. **Model 8LE-CO2** illustrated has 8 cu. ft. of free working space with 14" port in bottom for exciter head and two 2" entrance holes through wall. Mounted on 500-lb. capacity hydraulic lift for positioning. Temp indicating thermostat has range of —125° to +450° F, which can be extended to 600° with a high temp thermostat. Thirty-minute pull-down time with 50 lb. load to —65° F. Ambient to 450° F



with 50 lb. load of steel is 1½ hours. A 1/3-hp motor circulates air for uniform temp. Heat is provided by units of 375, 750 and 1,500 watts, selected with manual switch.

For More Information Circle EQ RSC #14

EQ's REPORT ON NEW PRODUCTS

Continues on Page 14

Deadline for New Product notices for the October issue is Sept. 1. Address your releases and photos to: "New Products" Editor, Environmental Quarterly, P. O. Box 2583, Grand Central Station, New York 17, N. Y.

COMPLETE
TESTING FACILITIES
with complete engineering
"KNOW-HOW"

ALTITUDE
TEMPERATURE
HUMIDITY
ACCELERATION
FUNGUS
RAIN
SUNSHINE
VIBRATION
EXPLOSION
SHOCK
SAND AND DUST
SALT SPRAY
RADIO NOISE
IMMERSION

As a pioneer in the design and development of equipment and "know-how" techniques in environmental testing . . . General Testing Laboratories offers you these advantages:

1 Our competent staff of engineers and technicians, many with a decade of experience in this line, are available for analyzing and helping you with your environmental testing requirements, in compliance with industrial and Government specifications including MIL-E-5272A and related tests.

2 To assure accurate and dependable tests, our modern, up-to-date equipment is devoted exclusively to giving quick service and reliable data for the proving of your products under any weather and environmental condition.

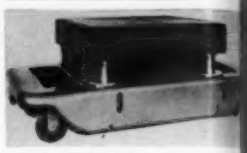
Phone or write today
for a personal discussion
of your test problems.

GTL
GENERAL TESTING LABORATORIES INC.
65 WASHINGTON AVE. CARLSTADT, N. J.
WEBSTER 9-6933

New Products

(Continued from Page 1

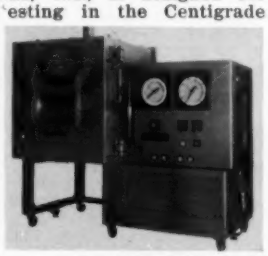
Oil film slip tables are being offered by **Ling Electronics, Inc.**, for use with Ling vibration testing systems. The tables consist of quality black granite, finished to surface plate standards and mounted on three vertical leveling pads over a steel tank which collects oil draining from the top of the granite. The oil allows the magnesium slip plate, fabricated to specimens, to slide in horizontal plane across face of the block.



For More Information Circle EQ RSC #15

* * * *

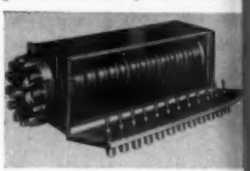
Chemosphere test chamber, Model FHV-27-5-5, by Conrad, Inc., is designed for testing in the Centigrade range between 100,000' and 260,000' altitude. Said to be the first commercially available unit to combine alt with temp and vibration with vibration machine coupled through a bellows to permit bolting test items in the chamber to the vibration table. Standard temp range is —100° to +300° F. Alt can be simulated up to 200,000' in 20 minutes; 500,000' can be attained at a rate of climb equal to 200,000' per min.



For More Information Circle EQ RSC #16

* * * *

Genisco 21 KV slip ring assembly by **Genisco, Incorporated**, consists of 12 slip rings and brushes designed to carry 50 milliamperes current at up to 21,000 v, ring to ring and ring to ground. Rings and terminals are proportioned to prevent corona, and terminals also serve as controlled air gaps which break down in the vicinity of 28 kv to protect against flashover. Rings are rhodium plated. Chrome-plated terminals accept banana plug, clip lead, wire end, wire loop and spade lugs. Complete assembly is 8x8x30".



For More Information Circle EQ RSC #17

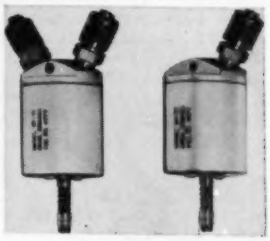
* * * *

Combination environmental chambers by **Tenney Engineering, Inc.**, have removable bottom hatch and replaceable silicone-coated diaphragm through which component can be mounted to head of vibration machine. Temp range —100° to +500° F. Mechanical or liquid CO_2 refrigeration. Available in **Tenney-mite** (for small components), **VT-10** (10 cu. ft.) and **VT-27** (27 cu. ft.) models. Insulated plug replaces diaphragm for temp testing without vibration. Fork lift mounting facilitates use with vibrator.

For More Information Circle EQ RSC #18

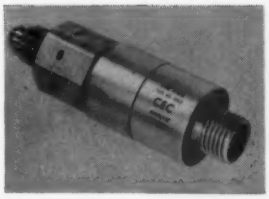
* * * *

Miniaturized pressure transducers in advanced versions of a series originally developed by **Northam Electronics, Inc.**, have been marketed by **BJ Electronics, Borg-Warner Corp.** which has acquired Northam. **Model GP-15D** is said to have achieved high resistance to mechanical shock and vibration because the pressure sensing diaphragm is the only moving part, being integral with the steel body. Available ranges from 10 to 6,000 psig. **Model DP-15** incorporates dual bleed screws. Available ranges from ±5 to ±5,000 psi differential at line pressures up to 5,000 psi. Type 431 stainless is primary material of both units.



For More Information Circle EQ RSC #19

Chamber-type unbonded strain gage pressure pickup by Transducer division of Consolidated Electrodynamics Corporation is said to retain accuracy at pressures to 10,000 psi absolute or sealed gage. Type 4-326 has provisions for adjustment of bridge balance, temp compensation and sensitivity in a chamber isolated from the sensing element. Each pickup can be adjusted to performance specs without affecting the precision, spring-type sensing element inside. Transducers with nominal output sensitivity of 40 mv are obtainable to operate in pressure ranges as low as 0-100 psi and in steps up to 0-10,000 psi. Operable temp rang is -320° to +300° F. Combined effects of linearity and hysteresis are less than ±.5% of full range output.



For More Information Circle EQ RSC #20

• • • •

Vibration exciter for conventional sine wave testing or for random or complex motion techniques under environmental conditions has been announced by MB Electronics division of Textron Electronics, Inc. The exciter, Model C125, is said to round out the company's line of integrated systems and to incorporate up to 40% more force output in the same size unit. Vector force output of 10,000 lb. Frequency range 5 to 2,500 cps. Weight of moving element about 100 lb. Axial resonance above 2,500 cps. Exciter is liquid cooled for environmental test chamber applications in ambient temps from -100° to +300° F. at alts to 250,000'.

For More Information Circle EQ RSC #21

• • • •

Electrical impact switch which registers shock from any direction within 90° of the vertical axis has been developed by the George Harmon Co., Inc. The switch, Model DWG 2-15, has only two moving parts. Features said to have been unavailable until now in impact switches include omni-direction actuation in the lower hemisphere, high current carrying capacity and provision for ground checkout. May be set for any value from 5 to 15 Gs or approximately 10 milliseconds. Weighs 20 ounces.

For More Information Circle EQ RSC #22

• • • •

Vertical, bench-mounted tensile tester, by Steel City Testing Machines, Inc. has 10,000 lb. capacity and can accommodate specimens up to 7" long. A 1/6-hp motor is wired for 110v, single phase 60-cycle AC. The unit, Model TE-10, comes with one set of jaws. Lower jaw holder adjusts to three positions. Two sizes of flat jaws, three of round jaws, compression plates and special gripping devices available. Can be converted to compression tests for specimens up to 4½ x 4".

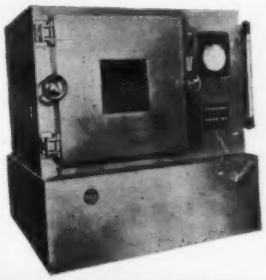
For More Information Circle EQ RSC #23

(More New Products on Page 30)

Standard CABINET COMPANY

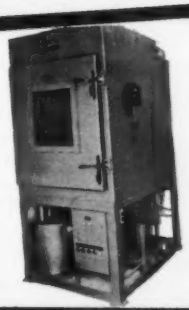
SPECIALISTS IN TEST EQUIPMENT

DESIGNED FOR DEPENDABILITY AND ACCURACY



TEMPERATURE
ALTITUDE HUMIDITY

Versatility plus dependability. −100°F, +200°F, 100,000 ft. altitude, 20% to 95% relative humidity. Other environmental extremes and walkin facilities to individual specifications.



RAIN AND SUNSHINE

Designed to MIL-E-5272A, Par. 4.9.1 and 4.10.1. Rugged construction . . . attractive appearance . . . self-contained . . . 18 cu. ft. and 36 cu. ft. chambers . . . walkin sizes to meet your specifications.

Dependable operation when you need it . . . Accuracy that is so necessary for correct tests . . . both are an engineering "must" that is built into every Standard test cabinet. Standard equipment available whatever simulated environmental condition is required . . . altitude, temperature, humidity, rain, fungus, sand and dust, salt spray or explosion. You will also find Standard Cabinet prepared to design and fabricate test units geared to your special requirements. Send for our illustrated brochure or, better still, call us right now . . . our engineers are at your disposal.

Write For Our Illustrated Brochure No. 59

Member of Environmental Equipment Institute

Standard CABINET COMPANY

49 Washington Avenue
Carlstadt, New Jersey
GEneva 8-1500

Task Equipment Analysis and Environmental Testing

While environmental testing tests for all expected environmental conditions, Task Equipment Analysis analyzes the environmental cycle for the stresses put upon equipment by man.

by

Max A. Pape

Operations Analyst, Stanford Research Institute

Reliability is a measure of performance—the degree of operational success that can be expected of any component, part, system, or subsystem. Helping to make sure equipment will work reliably in all anticipated environments is the function of environmental testing and part of the function of task equipment analysis.

Task equipment analysis exposes anticipated operational environments, measuring the environmental exposure from origin to end use and cataloguing different environments and degree of exposure. It is then that environmental testing can take over to test for ability to withstand those environments.

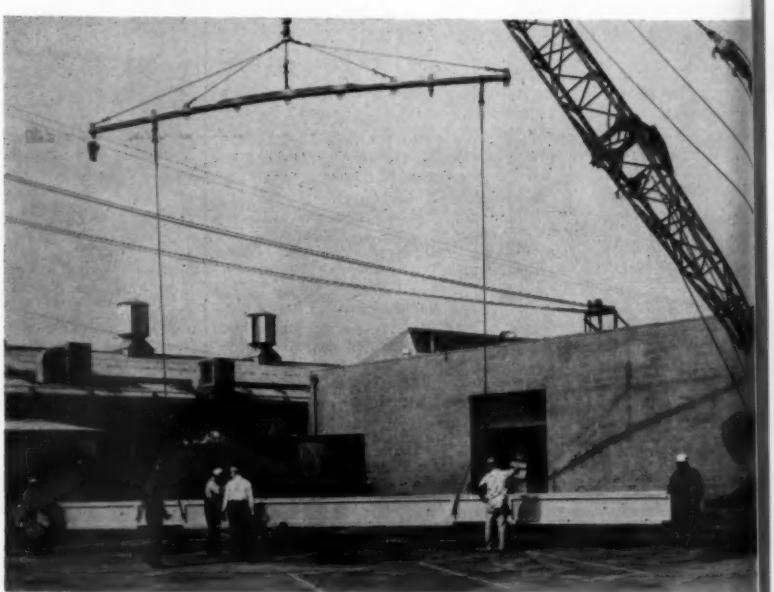
There is reasonable familiarity with environmental testing. Test metho for electronic equipment and co ponent parts, for instance, have be established by mil specs. By contra definition specific environmental r quirements must be worked out for a most all equipment manufactured u der government contract.

Naturally, the severity of vario environmental conditions depends o the specific item, and on where an how it is used. This is determined b task equipment analysis, which ma be described as a comprehensive anal sis of man-machine relationships f the purpose of supplying informatio that will assist in establishing equip ment and procedural design.

Task equipment analysis is a syst matic method of measuring deman

ENVIRONMENTAL SPECTRUM

Temperature (and rate of change)
(Temperature shock)
(Storage temperature)
Altitude (and rate of change)
Vibration
Shock
Acceleration
Humidity (and rate of change)
Sand/dust/dirt
Salt spray
Corrosion resistance
Fungus resistance
Sunshine (solar radiation)
Rain/hail/snow/sleet
Accelerated tests
Life appraisal tests
Wind
Blast
Accoustical noise
Atmosphere electricity
R. F. radiation
Transient environments



made by a machine on a human operator—and demands made by a human operator on a machine.

Although TEA is concerned with both of these demands, the primary concern is with the stress man puts on machine because this stress has a direct and influential bearing on reliability. It delineates a large part of the anticipated operational environments which become grist for the environmental testing mill.

Ideally, task equipment analysis starts the very moment a component, unit or part takes shape. It includes all data on handling, shock, vibration, movement, accidental dropping, dust, wind, noise and so forth, as suggested by the environmental spectrum, throughout the manufacturing process, on to the assembly, inspection, packaging, transporting and unpacking stages right into the hands of the using operator—and through to the stresses the using operator puts on it in use.

Every man-inflicted stress a component will undergo is categorized. After TEA has given the maximum amount of man-stress the component will be subjected to, there can be testing to see if the component will indeed stand up.

When a component fails it is returned to the design department. But it is quite possible that it simply cannot be redesigned because of the state-of-the-art. When that happens it becomes necessary to look at the demands the machine makes on man, instead of the demands man makes on machine. Human engineering takes over in the selection of personnel and writing of procedures which will "baby" the equipment. When design cannot be further improved, man must be trained to make up for design deficiencies.

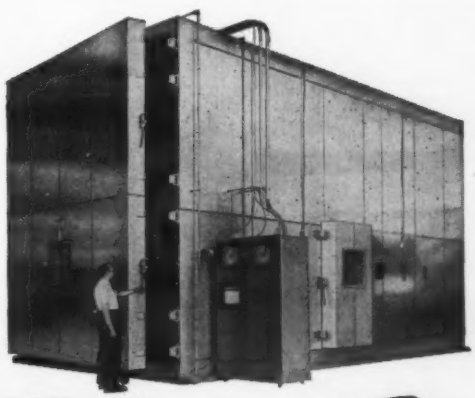
Task equipment analysis defines specific situations where operational personnel will tend to degrade the reliability inherent in the equipment. In addition, it helps to determine manpower needs, proficiency or level of performance required of people in technical jobs, flow patterns of essential work operations in the system, training requirements, descriptions of desirable training aids and devices and recommended procedures for operating and maintaining the system.

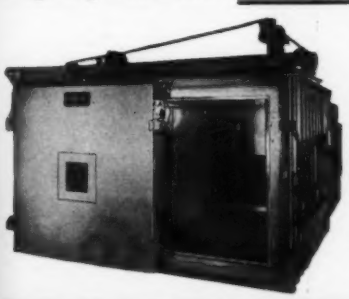
The environmental spectrum covers a wide range. However, components are tested only for the environments they are to be subjected to, with the usual safety factors taken into account. Finally there is operational testing to see if the component design will meet the reliability demanded of it by the customer. Reliability is the ultimate reason for and goal of both environmental testing and task equipment analysis.

When Max A. Pape was asked for biographical data he replied: "I have always felt that a realistic calculation of environments is an integral part of operational requirements, and therefore a requisite for effective system design. Consequently, I have been engaged in environmental engineering as long as I have been engaged in operational and logistic planning—14 years." Pape, who studied at the University of Washington, Seattle University, Heald's Engineering College, the University of the Philippines and Interamerican University, holds a Ph.D. in social sciences from Interamerican. He was formerly a senior research engineer with Lockheed's missile division.

AR

The most advanced testing techniques are being built into American Research equipment right now!





◀ Altitude, Temperature Humidity walk-in chamber 10′ high x 8′ wide x 12′ deep interior with push-button door controls inside and out.

Altitude chambers in any size — Altitude 200,000′ or higher; temperature +500°F and higher to −100°F and lower; Humidity 20% to 95%. ▶

▲ Prefabricated Temperature and Humidity walk-in test facility with test space 12′ x 25′ x 15′ high.

Sand and dust chamber ▶ includes automatic dust density control and stream-lined air-flow design.

AMERICAN RESEARCH CORPORATION
FARMINGTON 3, CONNECTICUT

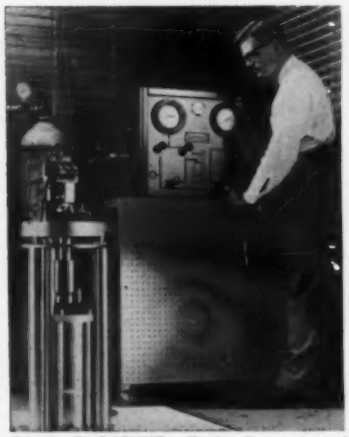
REPRESENTATIVES

Export: Maurice I. Parisier
741-745 Washington St.
New York 14, N. Y.

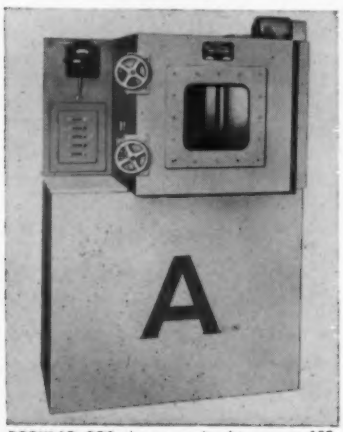
Maher Engineering Co.
4335 West Peterson, Chicago, Ill.

Computing Devices of Canada Ltd.
P.O. Box 508, Ottawa 4, Ontario Canada

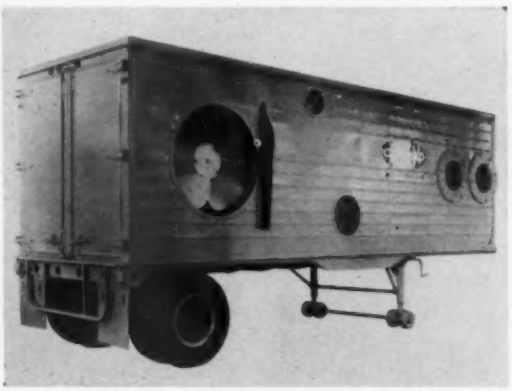
Environmental Quarterly's Album of Pe

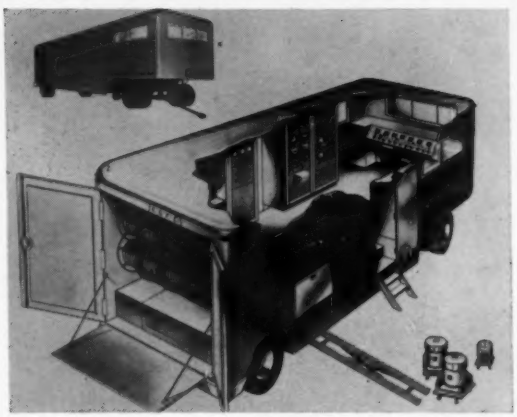


GOOD FIVE-CENTER: That's the estimated per test cost with **Consolidated Electrodynamics Corp.'s** new Hyge-6500 shock tester (above), using compressed bottled nitrogen. The unit can do either of two widely specified shock pulses in quick succession, a cycle a minute. **(For more info circle EQ RSC "D.")**



POPULAR CO2 shows up in this new —100- to +1,000° F chamber (above) by the manufacturing division of **Associated Testing Laboratories, Inc.** The unit, with working dimensions of 18x18x18" is said to be able to reach —100° F from ambient in less than three minutes, and at least 5000 BTU/hour can be dissipated within the chamber at —100° F. The chamber is priced at $1,250, plus optional features. **(For more info circle EQ RSC "E.")**





HIGH, WIDE AND — Artist's sketch (right) of the acoustics section of 28,000 sq. ft. environmental test lab being built for **Autonetics,** a division of **North America Aviation, Inc.** The acoustics lab will feature two 7,000-watt amplifiers coupled to 48 woofers and 64 tweeters to transmit high frequency sound through any of three separate sound chambers. Extremes of altitude, heat, cold, moisture, dryness and shock, acceleration and vibration will also be accomplished in the new lab at Downey, Calif.

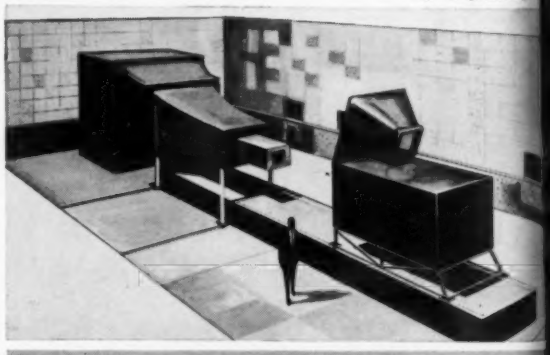
ROLLING ENVIRONMENTS: Mob... becoming more and more ...

In photo directly above, Donald ... Jr. (left) and Cameron G. Pierce ... respectively, of **Douglas Aircraft** ... **Ling Electronics, Inc.,** discuss the ... equipped for Douglas DC-8 jet ... bration testing a year ago. The ... is also being used on B-66 and ...

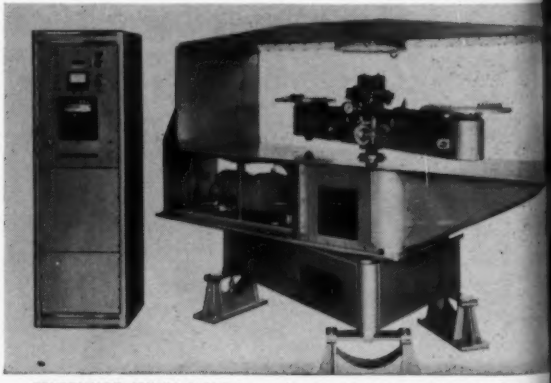
Conrad, Inc., unveiled its **Mob...** (above, left) a month ago. Design ... testing at any ground temperature ... ment, it supplies air condi... —100° to +300° F.

Propulsion Test Facilities, Inc.'s ... mobile (left) can operate and ... vibration exciters simultaneously. ... citers are supplied with ...

For more info circle EQ RSC "A ... "C," respectively.



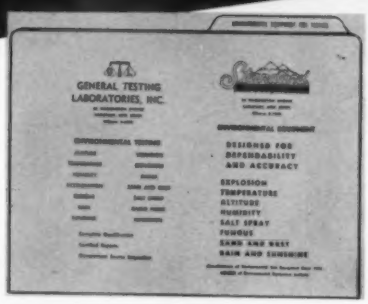
SANGUINE ENVIRONMENT, FOR A HEART: A patient undergoing a special heart operation needed 27 pints of A-plus blood, so 200 employees of **Bolock Instrument Corp.,** College Point, N. Y., turned out to contribute. Bolock's huge, spic-and-span environmental lab (above) was turned into an emergency ward as donors lined up amidst temp-alt-hum chambers, centrifuges, shakers, shock testers and another environmental gear.



CENTRIFUGE INNOVATIONS are being offered by **Genisco, Incorpo... its new Model A902.** The unit, designed for testing aircraft and mis... ponents under positive and negative G-effects and high ramp functi... tures two outboard rotating tables mounted on a boom. The table ... spatially-oriented while boom is rotating. **(For more info circle EQ R...**

...roducts, Places and Ideas...

ANNUAL IEE—NOW IES—MEETING ...environmental experts from all over ...country to Chicago's La Salle Hotel ...ast April. Above: a corridor scene.



ACCORDIAN FOLDERS (right) supplied by Standard Cabinet Co.—General Testing Labs helped visitors carry convention papers.

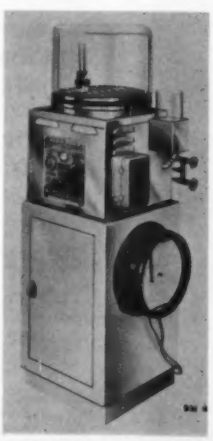
BARRY CONTROLS' "VARIPULSE" (above) attracted the attention of those seeking "shocks." Barry was one of 27 environmental equipment manufacturers participating in the trade exhibit.

...ON INDUSTRIES' Instrumentation Division had this (above) at the LaSalle, to the right of a display by B & K Instruments.

CONRAD, INC., introduced its versatile, portable "Temp-Rac 19" (above).

AMERICAN RESEARCH CORP.'s president, Jack Shamroth (left), and field application engineer, Martin Freitag, inspect their company's exhibit.

HIGH-LOW TEMP chamber with lifting jack for use with vibration unit, introduced by Murphy & Miller, Inc., is shown (at left) over a Ling Electronics machine.



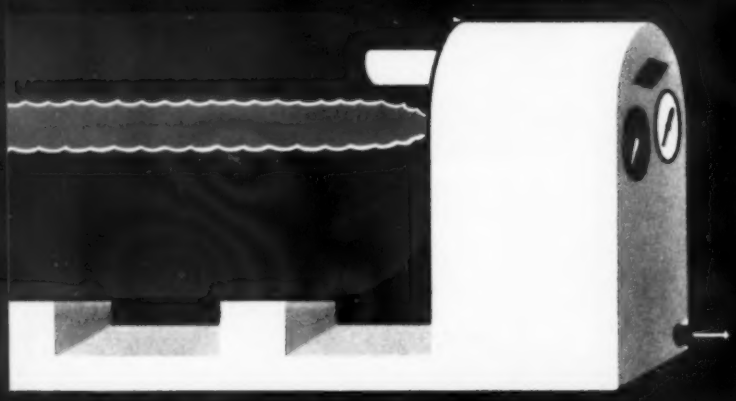
"VAPOR-TEMP" VP-200 controlled relative humidity chamber (right) by Blue M Electric Co., gave visitors a choice of baths and ovens...

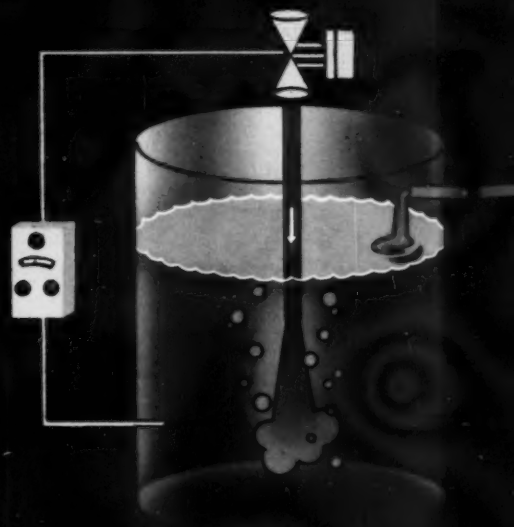
...NEAR THE CHILLING environments created by Cincinnati Sub-Zero Products. More than 700 persons reportedly visited the show's exhibit area.

FOR MORE ON THE TRADE SHOW—SEE PAGE 22

efficient . . . low cost . . . flexible e

From the smallest component parts to giant aircraft and missiles, Liquid Carbonic has the equipment . . . and the answers . . . to solve your low-temperature test problems. Your Liquid application engineer is only a phone call away, ready to help you any time. He can use your existing equipment or bring his own—and whatever your problem or product, he will gladly demonstrate the fast, easy Liquid method of handling it.

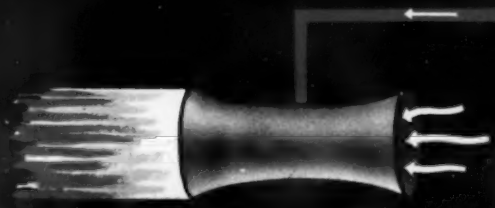




SUBLIMATION TANK

LIQUID'S INDIRECT SOLVENT SYSTEM

Ideal for fuel, vacuum, hydraulic fluid or altitude testing. This unique indirect system can be adapted to existing overloaded mechanical systems, and is suitable for cooling jet engine fuels or for such human factor testing as space suits. Here's the fast, easy way to make environmental low-temperature tests—resulting in better, more dependable products. For top performance wherever normal atmospheres must be maintained, Liquid's indirect solvent system is the answer.



OPERATIONAL UNIT

APPARATUS UNDER TEST

MULTIPLY YOUR ENGINEERING MANPOWER!

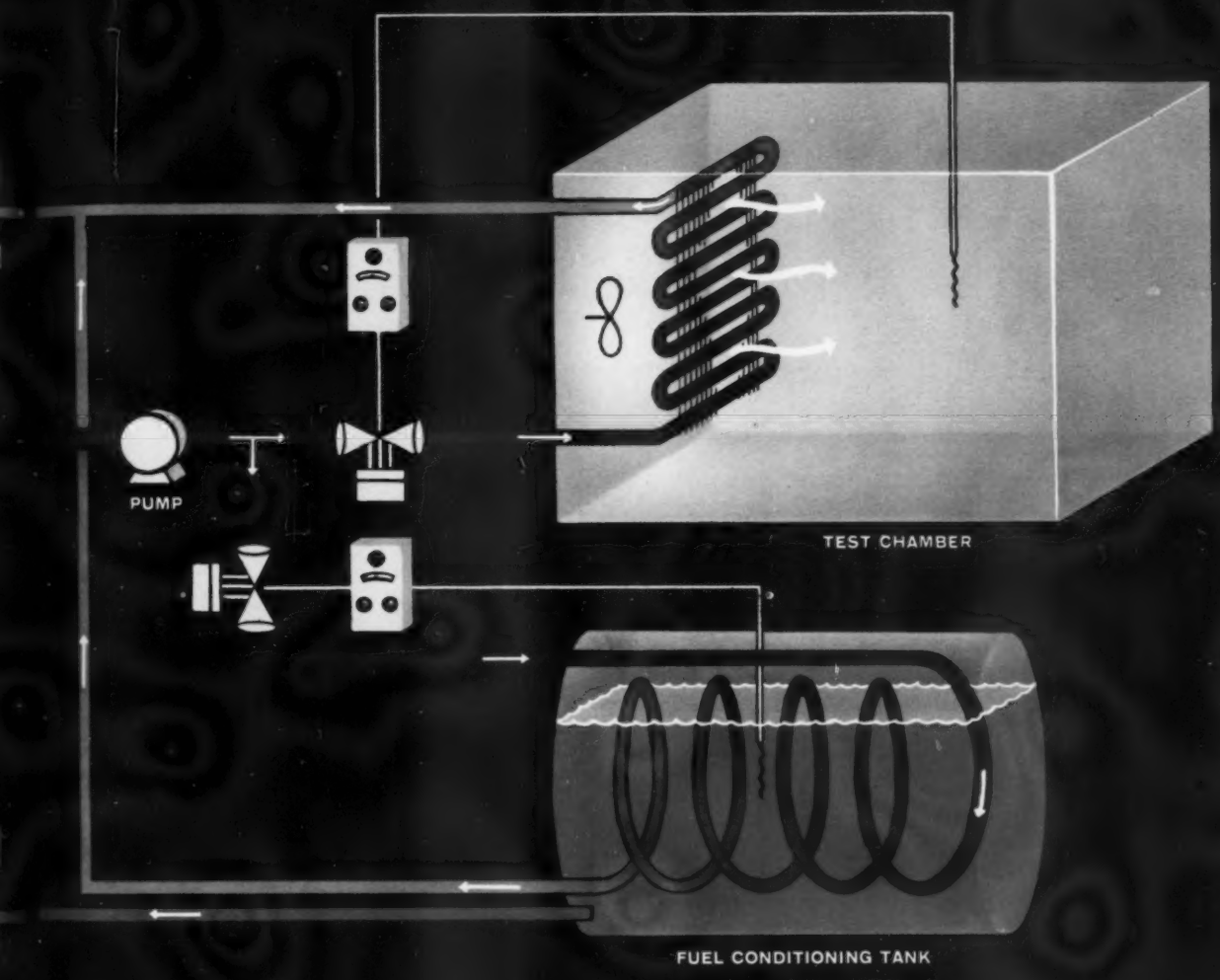
If your mechanical refrigeration unit is taking 8-10 hours to pull down from 200° F. to −65° F., CO_2 will do the same job in 8-10 minutes! Liquid's direct CO_2 injection pulldown to mechanical hold actually increases productive engineering time. Here is the ideal unit for your "fast-drop" tests to save both time and money.

Ask your Liquid Carbonic application engineer how *you* can save with a fast, improvised test on *your* product! Contact him today for a demonstration with this portable CO_2 testing equipment right in your own plant or laboratory at no obligation.

WORLD'S LARGEST PRODUCER OF CO_2

A Major Producer of Compressed Gases: Oxygen, Acetylene, Nitrogen, Hydrogen, Argon, Carbon Dioxide, Nitrous Oxide, Helium and Various Gas Mixtures.

e environmental testing with CO_2



DIRECT INJECTION

You can have unlimited refrigeration capacity with only a temperature controller and valve, chamber, and low-cost CO_2. In fact, for one ton of refrigeration per hour, you need only approximately one pound of CO_2 per minute! This handy unit is inexpensive and easy to operate, gives immediate pulldown to −109° F., and lends itself to simple automation.

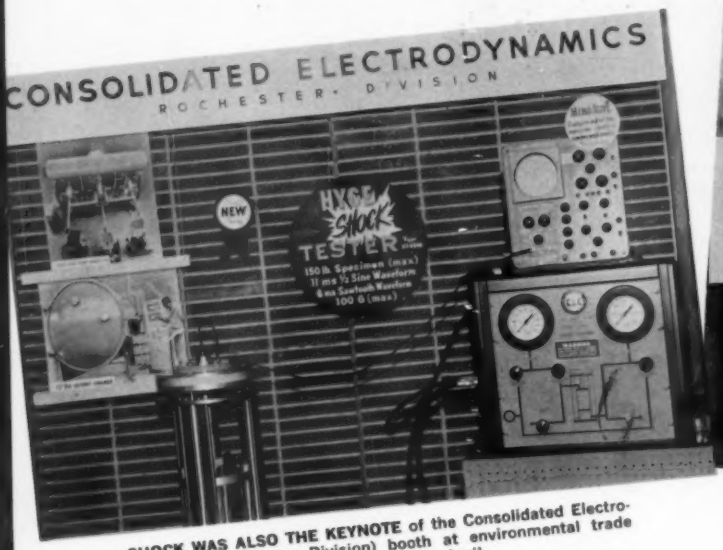
GENERAL DYNAMICS CORPORATION

GD CORPORATION | L-C DIVISION

Liquid Carbonic Division
135 South LaSalle Street
Chicago 3, Illinois

In Canada:
Liquid Carbonic Canadian Corporation, Ltd.

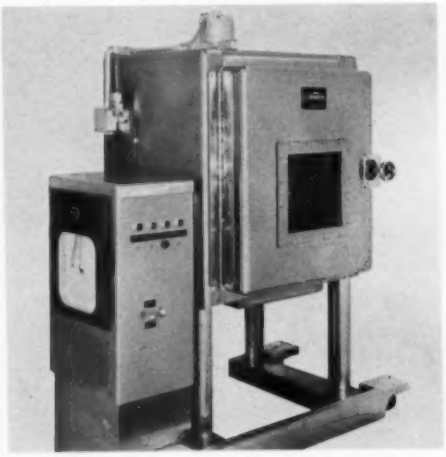
MORE FROM EQ's ALBUM OF THE TRADE SHOW (Cont'd from Pg. 19)



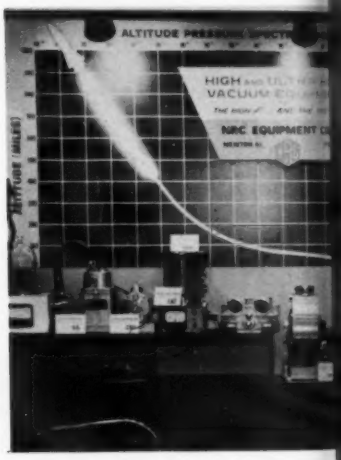
SHOCK WAS ALSO THE KEYNOTE of the Consolidated Electrodynamics (Rochester Division) booth at environmental trade show in Chicago last April.

CENTRIFUGES BY THE RUCKER COMPANY, "in person" and by photos, attracted convention attention. See Pages 4 and 35 for other news of the meeting.

DR. DANIEL POSIN (above, left) the Thursday luncheon speaker, is interviewed by a Chicago newsman.



STANDARD CABINET CO. exhibited a temperature test chamber (above) for use with exciters.



ULTRA HIGH VACUUM equipment was p displayed by NRC Equipment Corp.

HUDSON BAY CO. unveiled a "Hi-Lo-Frigid Cab" (above), capable of achieving —110° F is less than 5 minutes with a liquid CO_2 spray...

...AS LIQUID CARBONIC Division of General Dynamics Corp. (above) highlighted the growing popularity of rapid temp pull down with CO_2...

...AND A SELF-CONTAINED, portable, 1,0 liquid carbon dioxide storage unit (above) shown by Wyle Manufacturing Corp.

INTRODUCING THE

NEW

TEMPERATURE ALTITUDE HUMIDITY CHAMBER

- **Temperature Range** −120°F to +500°F
- **Altitude Range** Sea level to 200,000 feet
- **Humidity Range** 20% to 95% between +35°F and +200°F, limited by a low dewpoint of +35°F.

STANDARD WORK SPACE SIZES AVAILABLE

- 15" W x 21" H x 12" D
- 24" W x 30" H x 20" D
- 35" W x 36" H x 38" D

OPTIONAL ACCESSORIES AND INSTRUMENTATION AVAILABLE

- Viewing Window
- Interior Light
- Manual Wiper
- Electric Feed-Thru Terminals
- Access Port
- Casters
- Indicating Controllers
- Recording Controllers
- Program Controllers

Also available

LOW TEMPERATURE
HIGH TEMPERATURE
ALTITUDE
HUMIDITY
SALT SPRAY
SAND and DUST
VACUUM OVENS
WALK-IN ROOMS
FUNGUS

TEMCO INC.
18 BEECHWOOD AVENUE PORT WASHINGTON L.I. N.Y.

Power Spectral Density Nomogram

Measurement, analysis and application of random vibrations have received considerable impetus during the past five years. Previously vibration techniques were based primarily on sinusoidal vibrations.
Now that specs containing random vibration requirements have been set up in the missile programs, the application of random vibration theory is becoming more pronounced in that field.

by

ROY W. MUSTAIN

Senior Engineer, Shock, Vibration and Acoustics
Norair Division, Northrop Corporation

Random vibrations with continuous spectra are assumed to have instantaneous accelerations (in any frequency band) that display normal or Gaussian distribution. A normal distribution is defined by this noncumulative formula, where $\bar{x}$ is the mean and σ is the rms or standard deviation:

$$f(x) = \frac{1}{\sigma\sqrt{2\pi}} \exp\left[\frac{-(x-\bar{x})^2}{2\sigma^2}\right]$$

(Equation 1)

In random vibration theory the vibrations are assumed to be distributed about zero as a mean. Then the equation for the normal density becomes:

$$f(x) = \frac{1}{\sigma\sqrt{2\pi}} \exp\left[\frac{-x^2}{2\sigma^2}\right]$$

(Equation 2)

Assigning a value of one to σ, this equation is simplified to:

$$f(x) = \frac{1}{\sqrt{2\pi}} \exp\left[\frac{-x^2}{2}\right]$$

(Equation 3)

To illustrate, several popular statistical distributions have been plotted in Figures 1 and 2. In Figure 1, the noncumulative curve (Equation 3) of the normal distribution is symmetrical and bell-shaped. The area within the $\pm 3\,\sigma$ limits is equivalent to 99.7 percent of the total area and the turning points occur at $\pm 1\,\sigma$ values.

The cumulative normal distribution function is given by:

$$\text{cum } f(x) = \frac{1}{\sigma\sqrt{2\pi}} \int_{-\infty}^{x} \exp\left[\frac{-(x-\bar{x})^2}{2\sigma^2}\right] dx$$

(Equation 4)

This equation is frequently altered to show integration over the area from $-x$ to x instead of the area from $-\infty$ to x.

There are many tables in statistical literature with values for Equations 3 and 4, the ordinate and area, respectively, of the normal frequency curve. An excellent set prepared by the National Bureau of Standards contains precise values of the normal ordinate (Equation 3) and the normal area from $-x$ to x. These latter values, cum f(x; from $-x$ to $+x$), are related to cum f(x), Equation 4, as follows:

$$\text{cum } f(x) = \text{cum } f(x; -x \text{ to } +x) + \frac{1 - \text{cum } f(x; -x \text{ to } +x)}{2}$$

(Equation 5)

The ordinate (Equation 3) and area (from $-\infty$ to x) values for the normal curve have been plotted in Figures 1 and 2, respectively.

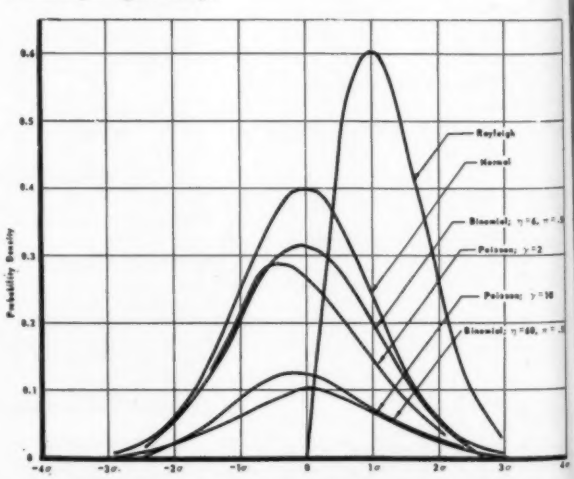


FIGURE 1 — PROBABILITY DENSITY PROPORTIONS

In 1877 Lord Rayleigh provided an early foundation for modern theories on stochastic (random) methods. In "The Theory of Sound," he discussed vibrations with "phase accidentally determined" and formulated the circular distribution that describes the amplitude r, or envelope of random vibrations. The Rayleigh distribution shows the probability of a resultant amplitude occurring between r and r+dr when a large number, n, of unit vibrations are compounded at random. This is how the probability was given originally by Rayleigh:

$$\frac{2}{n\alpha^2} \exp\frac{-r^2}{n\alpha^2} \; r\,dr$$

(Equation 6)

For power spectra mathematics this probability can be expressed in the modern form:

$$P(r)\,dr = \frac{r\,dr}{\sigma^2} \exp\left[\frac{-r^2}{2\sigma^2}\right]$$

(Equation 7)

The probability of a resultant amplitude less than r was given by Lord Rayleigh as:

$$2n^{-1}\int_0^r \exp\left[\frac{-r^2}{n}\right] r\,dr = 1 - \exp\left[\frac{-r^2}{n}\right]$$

(Equation 8)

Thus, the probability of a resultant amplitude greater than r is:

$$\exp\left[\frac{-r^2}{n}\right]$$

(Equation 9)

and in modern notation this becomes:

$$P(\text{envelope} > r) = \exp\left[\frac{-r^2}{2\sigma^2}\right]$$

(Equation 10)

The probability density function expressed by Equation 7 is presented graphically in Figure 1. The cumulative distribution of Equation 10 has been calculated and plotted in Figure 2, for values of σ vs. probability.

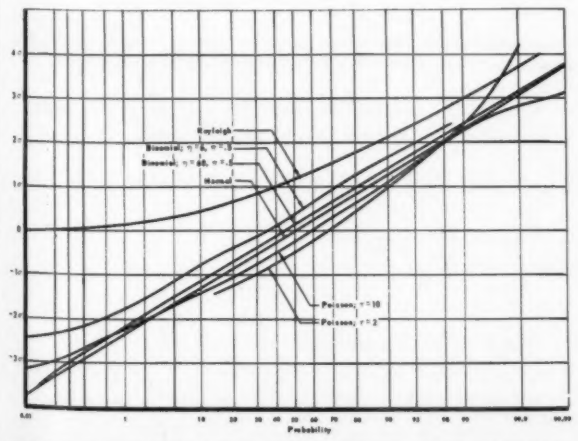
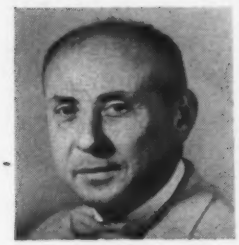


FIGURE 2 — CUMULATIVE PROBABILITY DISTRIBUTIONS



Mustain

To go by the headlines, rockets, missiles and related achievements are of recent vintage. Headlines never mention scientists and engineers like Roy Mustain, who have been studying, working and probing for years to make today's spectacular feats possible. Mr. Mustain's experience goes back to World War II and before. As his resume puts it, he studied at Los Angeles City College, U. C. L. A. and U. S. C. and he has "attended numerous extension courses over a continuous period of 25 years." Now in his sixth year with Norair as a senior engineer, his current primary concern is with the definition of dynamic environments and their application to the SM-62 Snark missile.

In vibration terminology, r is the symbol for peaks of the instantaneous accelerations and σ is the rms instantaneous acceleration. Peak accelerations are distributed according to the Rayleigh law when the instantaneous accelerations are normally distributed. This condition is true for either wind-band or narrow-band Gaussian noise.

Random vibrations may be analyzed by measurements of either instantaneous or peak values. Instantaneous measurements are usually obtained with true rms meters that provide σ or rms values to define the vibration distribution of the bandwidth being investigated. These σ values are usually plotted on power spectral density charts for values of power spectral density in g^2/cps wherein power spectral density $= \frac{\sigma^2}{\Delta f}$, where Δf is the bandwidth of the filter used to obtain σ. Elaborate data reduction systems are presently available that automatically record XY plots of g^2/cps vs. frequency.

Another type of reduction system compiles statistical data by counting the peak pulses in the bandwidth being analyzed. This device supplies sufficient test points to establish the vibration distributions (for peak vibrations) comparable to the Rayleigh law.

It is more convenient to deal with the peak measurements if the data being investigated have a narrow band. This condition may be the result of filtering action caused by local structural resonances, acoustic and vibration inputs, or electrical network conditions.

The normal and Rayleigh distributions are of the utmost importance in the analysis of vibration and power spectra. They present the possible extremes of (peak) data distributions for some missile vibrations.

Acoustic excitations generated by solid propellant boosters on missiles display continuous frequency spectra

(Continued on Page 26)

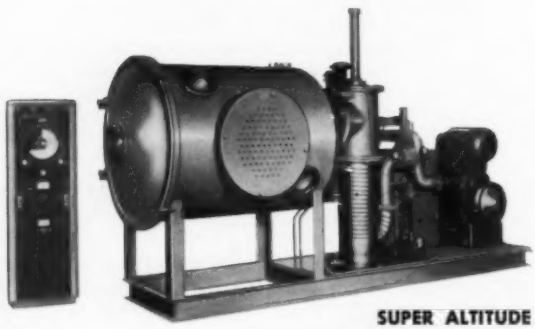
everyone talks about

"RELIABILITY"...

MURPHY & MILLER

BUILDS IT!

Long before "reliability" became the magic word in describing every conceivable type of equipment, Murphy & Miller was building environmental test equipment that delivered reliability in terms that could be measured: CONTINUOUSLY ACCURATE PERFORMANCE UNDER THE MOST RIGOROUS OPERATING CONDITIONS. (We will always build reliability into everything that bears our name.)



SUPER ALTITUDE SIMULATION CHAMBER

- Sea Level to 350,000 ft. (760 MM Hg to ½ Micron)

COMBINED TEMPERATURE and VIBRATION SIMULATION TEST CHAMBER

- Sizes 1 to 64 cubic feet
- Temperature Range: —120°F. to +500°F
- ALL STAINLESS STEEL TEST SPACE
- Optional Recording, Controlling, and Programming Equipment Available
- Self Elevating Chamber Available (Optional)

COLD TEST CHAMBER

- Temperatures to —200°F
- Stainless Steel Test Space
- Forced Air Circulation
- Heating cycles available to 300°F
- Test space capacities start at 1 cu. ft.

For the *best* in environmental test equipment, check Murphy & Miller first. Write for illustrated circular.

murphy & miller, inc.
622 West Taylor Street • Chicago 7, Illinois
Engineering Representatives In All Principal Cities

MEMBER OF ENVIRONMENTAL EQUIPMENT INSTITUTE

Power Spectral Density

(Continued from Page 25)

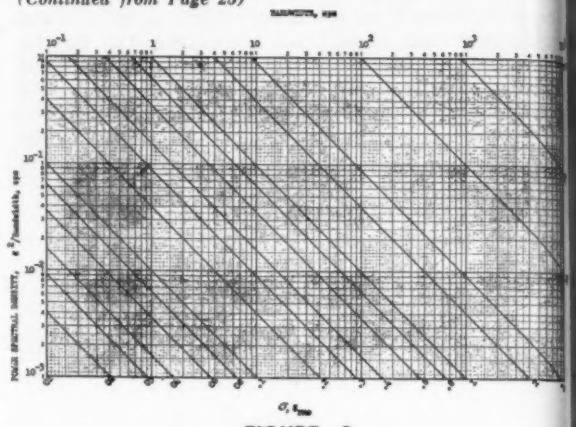


FIGURE 3

that are converted into more discrete spectra within the missiles. It can be expected that the random vibrations, induced within the missile skin, the missile structure, and the missile equipment will depart (in varying degrees) from the uniform distribution shown by the booster noise.

Instantaneous accelerations will display a normal distribution or slight modifications, and the corresponding peaks will reflect the Rayleigh law within certain limits. The excitations of the narrow bands, caused by structural filtering, may also exhibit peak distributions in agreement with the Rayleigh or "circular" case.

Actual field data indicates that there is a tendency for the peaks in the narrow bands to follow other distribution patterns. The probability density of the peak envelope (r) will vary from Rayleigh to Gaussian as the narrow-band waves assume stages of all noise, noise plus sine, and all sine components. The sine/noise ratio may vary from zero to infinity.

Determination of three related parameters is usually required in the reduction and analysis of random vibration data. The following nomogram has been derived for the purpose of relating the power spectral density in g^2/cps, the σ or rms instantaneous acceleration, and Δf, the bandwidth of the filter used to obtain σ. In technical literature, several symbols have been used to represent power spectral density: F, G, W, and $\sqrt{\psi}$. Here, the symbol G is being used, because it comes closest to implying acceleration.

Values for the power spectral density nomogram have been calculated from the following basic formula:

G = mean squared acceleration density or power spectral density in g^2/cps.

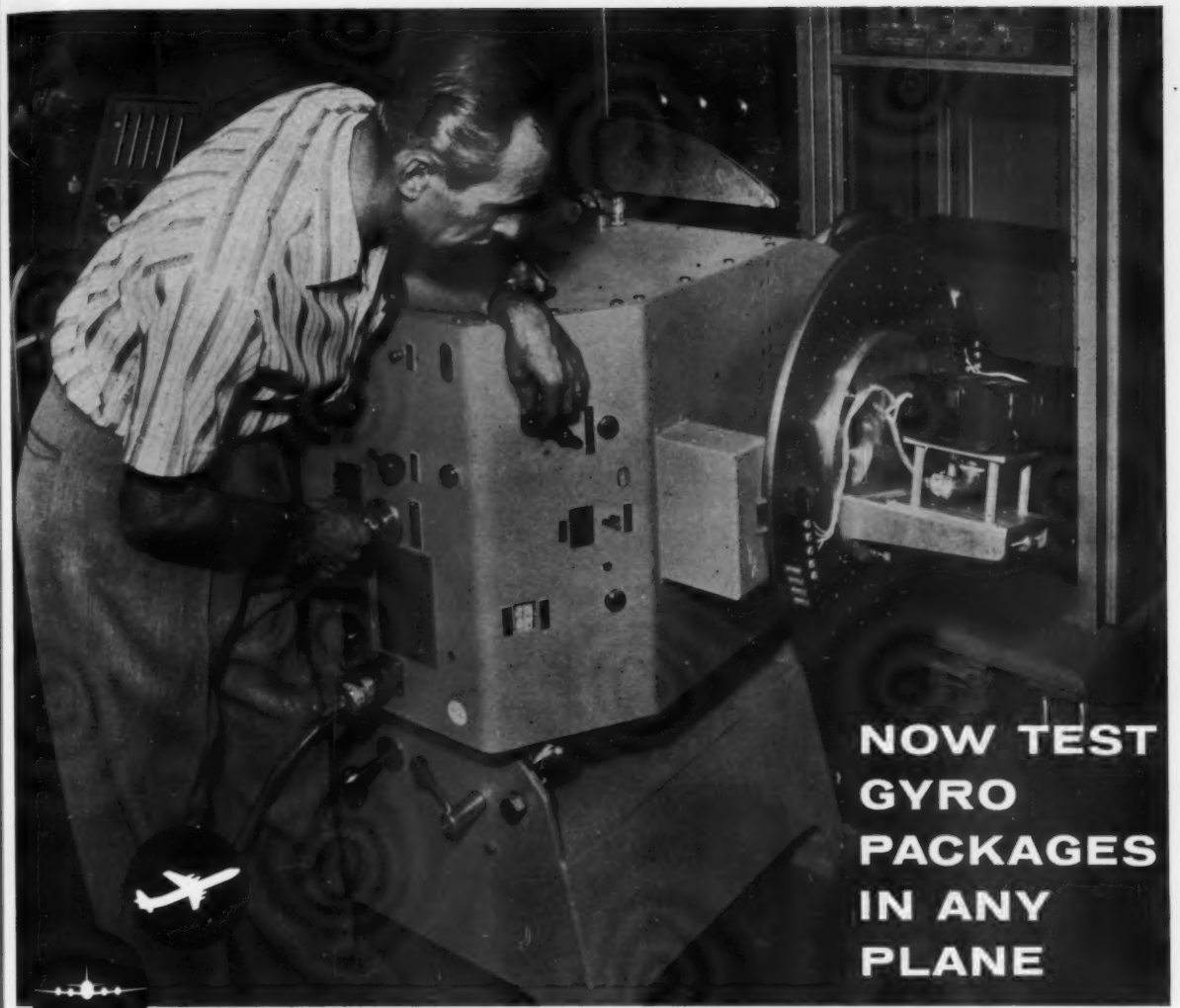
σ = root mean square acceleration between $f_1 - f_2 = \Delta f$

$$\sigma = \sqrt{\int_{f_1}^{f_2} G \, df}$$

$$\sigma^2 = \text{acceleration variance} = \int_{f_1}^{f_2} G \, df$$

$$G = \lim_{\Delta f \to 0} \frac{\sigma^2}{\Delta f} \qquad G = \frac{\sigma^2}{\Delta f} \text{ in } g^2/\text{cps}$$

(Continued on Page 31)



New accessory permits Genisco C181 Rate of Turn Table to be operated at any angle from horizontal to vertical

Fred Davenport, Lockheed radio-radar technician, tests pitch-yaw gyros used in the *Electra*, Lockheed's fast, new prop-jet, on the first *tiltable* Genisco C181 Rate of Turn Table.

A new, vertical-drive accessory permits the C181 to operate in *any* position. Now, gyros or complete gyro packages can be tested at any angle up to 90° from horizontal, either side of center, without changing the test set-up.

With the accessory installed, overall performance of the turntable is unaffected by its position. Rotation is infinitely variable from 0.01° to 1200° per second. Constancy of angular velocity is within 0.1%, including wow and drift errors.

The new vertical drive accessory can be installed at the factory, and is also available in kit form for modification by users of machines already in the field. The new tilt stand (shown above) provides a convenient method of tilting and accurately positioning the machine at any angle.

Detailed information on both the vertical drive accessory and tilt stand is available and will be sent upon request.

More than 400 Genisco Rate of Turn Tables are now in use.

ACCESSORIES ADD TO ACCURACY AND CONVENIENCE OF THE C181

Braking System—Generates a step impulse of angular deceleration. Particularly useful in evaluating damping characteristics of rate gyros and angular accelerometers.

Precision Strobe—For use in monitoring rates where line frequency is questionable or where gyro accuracy is better than line frequency.

Slip Clutch—Allows table to be stopped by hand for minor adjustments to test package while drive system continues to operate.

Low Rate Readout—For accurate rate indication below 10°/sec.

Mounting Stands—Available in portable, fixed and the new tilt models.

Genisco INCORPORATED

2233 FEDERAL AVENUE • LOS ANGELES 64, CALIFORNIA

People You Know...

CHANGING ENVIRONMENTS

JAMES A. ROSS, vice president of LING ELECTRONICS, INC., has become chief engineer with responsibility for R & D at the main Ling facility at Culver City, Calif., and at the former Calidyne operation in Winchester, Mass., which Ling acquired several months ago. In other top-level assignments stemming from the Calidyne consolidation, **CHARLES THEODORE,** vice president-sales, assumed overall sales-service direction in both eastern and western regions for the manufacturer of power amplifiers and vibration testing systems, and **STANLEY H. WALTERS,** former Calidyne vice president, became Ling's eastern regional sales manager.

GERALD C. WATERMAN, manager of systems at CONSOLIDATED ELECTRODYNAMICS CORPORATION's Rochester division for three years, has been named manager of the Washington, D. C., regional office of Consolidated Systems Corp., a recently organized, wholly owned CEC subsidiary. At the Rochester division, **DEAN B. ARLIDGE** has been promoted to the post of manager of technical services. He had been an application engineer with the division since 1956.

IAN WILLIAMSON and PAUL S. GOODWIN are recent additions to personnel at LING ELECTRONICS, INC. Williamson, who had been in charge of the acoustics and vibration group in the testing division, aircraft and missiles, at Douglas Aircraft, is Ling's manager of field service engineering. Goodwin is special staff assistant to the chief engineer with duties as senior project engineer for underwater sound systems.

FRED E. BRADSTREET, T. C. WARNER JR. and CHARLES E. MAKI have won promotions at MB ELECTRONICS, New Haven. Bradstreet, who has been with the company 11 years, is now sales manager of the new Isomode division, which is responsible for the manufacture, distribution and sale of MB's complete line of vibration isolating products. Warner, who developed a single frequency pickup calibrator for onsite application that has been accepted as a standard by the Armed Services and the Bureau of Standards, has been named chief development engineer of the electro-mechanical section of MB's vibration equipment division. Maki has been appointed chief development engineer and head of a new accessories group. The group is responsible for special orders and accessories, such as field and degaussing supplies and amplitude protectors.

Williamson

Bradstreet

Goodwin

Warner

Maki

Sieling

DALE H. SIELING, dean of the University of Massachusett's college of agriculture, has been appointed scientific director of the Army Quartermaster Research and Engineering Command, Natick, Mass. He also directs scientific efforts at the QM Food and Container Institute, Chicago; the QM R & E field evaluation agency at Fort Lee, Va., and the QM Radiation Planning Agency, Washington, D. C.

HAROLD A. MOSHER, associate director of engineering at the Kodak Park Works of EASTMAN KODAK COMPANY, has been elected president of the National Society of Professional Engineers. He is a member of the American Society of Mechanical Engineers and the American Society of Air Conditioning and Ventilating Engineers.

C. S. DRAPER, head of the department of aeronautics and astronautics, Massachusetts Institute of Technology, has been named chairman of the National Inventors Council, succeeding the late Dr. Charles F. Kettering. Dr. Draper is a pioneer inventor of inertial guidance systems.

GEORGE A. DOWNSBROUGH, president of the BOONTON RADIO CORPORATION, has been elected president of the Scientific Apparatus Makers Association.

MAJ. GEN. RALPH T. NELSON, has been appointed as the 18th chief signal officer of the U. S. Army.

JAN MUELLER is the new manager of jet engine component manufacturing for AMERICAN METAL PRODUCTS CO., Detroit. He joined AMP as a draftsman in 1951.

JAMES V. CRAWFORD is now chief engineer and **NORMAN M. BROWN** is assistant chief engineer at the GARRETT CORPORATION'S AiResearch Manufacturing division in Los Angeles. Promotions at the AiResearch division in Phoenix resulted in **DR. HELMUT SCHELP** being named chief engineer; **CARL PAUL,** assistant chief engineer, and **C. F. BLANDING,** engineering manager.

Temperature/Humidity YOUR PROBLEM?

Solve it at *amazingly low prices*

with BLUE M

(Constant-Flow Design)

Mechanically Refrigerated

Counter-Flow

All Stainless Steel

CONTROLLED RELATIVE HUMIDITY CABINETS

Featuring

A NEW PROVEN SYSTEM

- Dry Bulb 35° F. to 185° F. (± 2° F.)
- Humidity Control 40% to 98% (±2%)
- Shielded Conditioning Chamber
- Low Voltage Control Circuit
- No Wet Bulb Wick to Change
- Inner Glass Door—Alloy Latches

Completely self-contained . . . no water necessary as coolant . . . ready to use and fully automatic

Patents Pending

4 Models 1.5 to 10.0 cu. ft.

$1885.00 to $3275.00

BLUE M Electric Company BLUE ISLAND, ILL.

MANUFACTURERS AND DESIGNERS COMPLETE TEMPERATURE CONTROL EQUIPMENT

Partial view of a 10' x 10' x 35' low temperature test chamber built by the Mantec Division of Wyle Manufacturing Corp., El Segundo, California. Bulk liquid PURECO CO_2 can bring the interior down to —110° F. in minutes.

PURECO CO_2 puts the *freeze* on Wyle test chambers

Inside this low temperature chamber at Wyle Laboratories, missile and aircraft mobile ground support test units are subjected to temperatures plunging well below arctic fare.

The best refrigerant for this important test job is PURECO CO_2 in bulk liquid or solid form ("DRY-ICE"). It can be ACCURATELY CONTROLLED, is MAINTENANCE-FREE, CONVENIENT, RELIABLE and LOW IN COST.

Wyle standardizes on PURECO CO_2 because PURECO means *dependability of supply* and know-how.

PURECO'S Technical Sales Service is qualified to assist you in adapting CO_2 to any particular refrigeration or inerting application. Call your PURE CARBONIC representative. There are more than 100 PURECO locations from coast to coast.

PURECO CO_2

Pure Carbonic Company

A Division of Air Reduction Company, Incorporated

150 EAST 42ND STREET, NEW YORK 17, N. Y.

Seismic Pickups

(Cont'd from Page 11)

the range covered by such an instrument. In vibration measurement work where some phase distortion is acceptable, velocity pickups are usually damped to about this level. For shock measurement, a virtually undamped pickup is desirable and may be used, providing the resulting amplitude of response near resonance can be tolerated mechanically.

Transient Response

The above analyses are based upon steady-state, sinusoidal excitation. In the transient case the fact that there is no unique basis for assigning a particular "equivalent" frequency to a pulse of acceleration – and that no one parameter of the pulse (peak acceleration, impulse, etc.) is of definitive significance in terms of the response of a wide variety of structural elements to the motion – makes it difficult to develop simple criteria for expressing instrument fidelity in quantitative terms. Specific cases analyzed by numerical and analog methods, however, provide some qualitative guidance for assessing the instrument characteristics needed to resolve a particular type of motion adequately.

For example, Figure 7 shows the response of an accelerometer subjected to half-sine pulses of duration T_o. If their equivalent frequency ω_{eq} is considered to be ω/T_o (in effect, fitting a steady-state sinusoidal motion to the pulse), it will be seen that the initial rate of rise of the pulse causes considerable excitation of the natural response of the undamped instrument even at ω_{eq}/ω_n ratios as low as .10, with corresponding errors in instantaneous and peak response values much in excess of those that would be predicted from steady-state curves (Figure 3). For this reason, the use of undamped pickups, even of very high natural frequency, is usually unsatisfactory for transient measurements unless a low-pass filter is used.

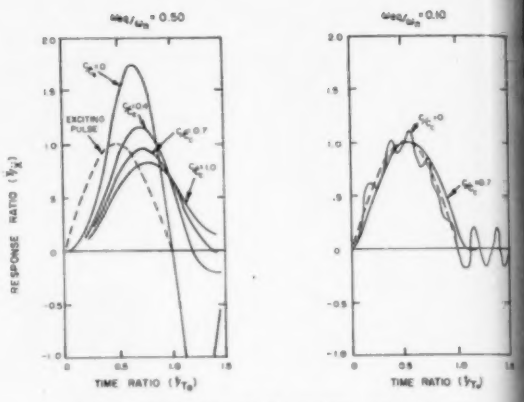


FIG. 7 DYNAMIC RESPONSE OF IDEALIZED LINEAR PICKUP

(Response curves for accelerometers with varying degrees of damping subjected to single half-sine pulses. Pulse on left is of "equivalent frequency," about one-half the natural frequency of the instrument; pulse on right is of about one-tenth instrument frequency.

The addition of damping of about .7 critical greatly improves the situation. In practice, it may also be possible to improve the record of a transient by shifting the time base slightly to compensate for phase lag and by fairing out of the signature recognizable components of instrument response frequency.

It is the conclusion of those who have studied transient response that for typical pulse shapes (half-sine, triangular, square), an accuracy of peak reading of 5 percent can be maintained only in an instrument with damping from .4 to .7 critical whose natural period $1/f_n$ is about one-third or less the pulse duration ($\omega_{eq}/\omega_n = .16$ on the above basis).

New Products

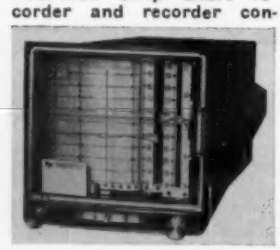
(Cont'd from Page 15)

Explosion-proof differential pressure control, Type J94K, is announced by **United Electric Controls Co.** for use in presence of explosive gases or vapors to find the difference between two separate pressures or vacuums. Several system differentials available between 30" hg and 40 psi, with switch differentials from .5 ±1/10" hg and up. Weighs about 25 lbs. Switches are single pole, suitable for ambient temps to 100° F. and rated 15 or 20 amps, 115/230v AC. Switch actions include normally open, normally closed or double throw with no neutral position. Manual resets also available.

For More Information Circle EQ RSC #24

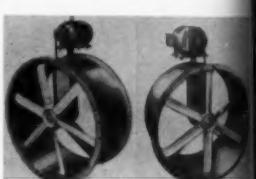
* * * *

Four-inch strip chart recorder and recorder controller by Fischer & Porter Co. feature modified inking for month's record without refill and new pen mechanism. The **Mark III** line also features a flip switch for reversing controller action from air to open to air to close, 14 hours' visible chart record, built-in damping of pneumatic input signals and reinking without interfering with movable parts.



For More Information Circle EQ RSC #25

High temperature exhaust fans for exhaust hoods and oven air seals by **Binks Manufacturing Co.** are said to operate at top efficiency at temps from -40° to +400° F. Fan and pipe sizes range from 18" to 42". Free air delivery ranges from 3,180 to 29,500 cfm. Fans are of six-blade aero type. Motor hp requirements range from ¼ to 7.5. Shown are double mount type at left, single mount at right.



For More Information Circle EQ RSC #26

The American Association for the Advancement of Science administers a Traveling High School Science Library Program, sponsored by the National Science Foundation, to stimulate interest in and choice of careers in science.

It has been estimated that the world will use five times as much energy in the year 2,000 as it does today. It will need the equivalent of 2,000,000,000,000,000 barrels of oil each year.

There are some 1,506 different scientific and technical professional groups and societies in the United States and Canada. Each represents a separate field of scientific specialization.

Robert Hooke, mechanical assistant to the man who established Boyle's law of physics, invented a device to measure the atmosphere's moisture, a wind-velocity gauge, a registering rain gauge, and a clock-driven telescope.

Po

(Co

Ex

Gi

Re

So

σ

σ

in

E

G

R

S

th

a

le

E

G

R

S

g

c

c

n

V

J

Power Spectral Density

(Continued from Page 26)

Example 1

Given: $G = .01\ g^2/cps$; $f_1 = 100$ cps; $f_2 = 200$ cps

Required: σ

Solution:

$$\sigma = \sqrt{\int_{f_1}^{f_2} G\ df} = \sqrt{\int_{100}^{200} .01\ g^2/cps\ df} = \sqrt{.01 \times (200-100)}$$

$$\sigma = \sqrt{1} = 1 g_{rms}$$

This solution may be verified on the nomogram by inserting $.01\ g^2/cps$, $\Delta f = 100$, and finding $\sigma = 1$.

Example 2

Given: $\sigma = 2 g_{rms}$; $\Delta f = 20$ cps = bandwidth

Required: mean squared acceleration density, G

Solution: $G = \dfrac{\sigma^2}{\Delta f}$

$$\frac{(2)^2}{20} = 0.2\ g^2/cps.$$

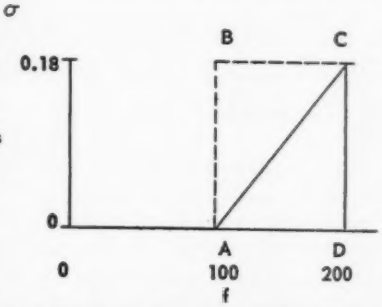
Again, this solution may be verified by inserting into the power spectral density nomogram the values of $\sigma = 2 g_{rms}$ and $\Delta f = 20$ cps. The answer $0.2\ g^2/cps$ may be read from left hand ordinate scale.

Example 3

Given: a mean squared acceleration density that varies linearly from zero at 100 cps to $0.18\ g^2/cps$ at 200 cps.

Required: σ

Solution:



Note that the mean squared acceleration density as given in the problem represents the area $\frac{ABCD.}{2}$. Therefore,

$$\sigma = \sqrt{\int_{f_1}^{f_2} \frac{G}{2}\ df} = \sqrt{\int_{100}^{200} \frac{0.18}{2}\ df} = \sqrt{0.09(100)}$$

$$\sigma = 3 g_{rms}$$

This solution may be verified by inserting into the nomogram the values of $0.09\ g^2/cps$ and $\Delta f = 100$ cps. The value of $3 g_{rms}$ is found on the abscissa of the nomogram.

ELECTRONIC SPEED CONTROL EXCLUSIVELY ON RUCKER SMALL CENTRIFUGES

To Meet Your Requirements For Acceleration Testing Under MIL-E-5272 A Procedures I and II

The new electronic speed control circuit — an exclusive feature on Rucker Series I Centrifuges, provides:

- ✓ DIGITAL CONTROL SETTING: Only one setting required to reach any desired speed.
- ✓ PROGRAMMED SEQUENCE OR REMOTE OPERATION
- ✓ G RATING REPEATABILITY
- ✓ DEPENDABLE, QUIET OPERATION
- ✓ FAST TEST CYCLE
- ✓ AUTOMATIC OR PROGRAMMED DYNAMIC BRAKING

OTHER RUCKER FEATURES:

- ✓ EASIEST ACCESS TO SPECIMEN AND INSTRUMENTATION
- ✓ MINIMUM WOW AND DRIFT THROUGH HIGH INERTIA DESIGN
- ✓ HEAVY STEEL CONSTRUCTION THROUGHOUT FOR MAXIMUM SAFETY
- ✓ ELECTRICAL SLIP RINGS
- ✓ CAPACITIES TO 15,000 G POUNDS, 92 INCH DIAMETER
- ✓ 90° SPECIMEN ROTATION DURING OPERATION (Procedure I under MIL-E-5272 A)—(Optional)
- ✓ WAVE GUIDES FOR ALL APPLICATIONS (Optional)
- ✓ CLOSED CIRCUIT TV (Optional)
- ✓ HYDRAULIC-PNEUMATIC ROTARY JOINTS (Optional)

Rucker Series 10 and 20 Centrifuges also available with capacities in excess of 450,000 G pounds and diameters to 70 feet.

The RUCKER Company
Since 1941
4700 SAN PABLO AVENUE • OAKLAND 8, CALIFORNIA
ATTENTION: *Openings now for Qualified Engineers— for Design and Sales*

LITERATURE FOR ENVIRONMENT...

AEROTEST LABORATORIES, Inc., is offering a useful, compact designers' wall chart free of charge. The finger-tip handbook contains conversions factors, a table of fraction equivalents, a standard atmosphere table and other such data. **(Circle EQ RSC #41)**

* * *

ERIC A. LINDGREN AND ASSOCIATES describe their RF shielded enclosures in a two-color, four-page, easy-to-read bulletin. **(Circle EQ RSC #42)**

* * *

CONRAD, Inc, has issued an eight-page brochure picturing its temperature and temperature-altitude vibration test chambers. Featured is Conrad's new Chemosphere unit for testing aircraft and electronic equipment between 100,000 and 200,000 feet. **(Circle EQ RSC #43)**

* * *

CHADWICK-HELMUTH Co.'s Slip-Sync system for visual and photographic study of vibration tests is explained in a two-color six-page brochure. Information given includes how to trace destructive resonances, improve jig design, photograph high-speed subjects and calibrate accelerometers. **(Circle EQ RSC #44)**

* * *

KOEHLER/DAYTON valves and other products for aircraft, missile and industrial applications are listed in a new catalog with a unique "selector index." **(Circle EQ RSC #45)**

AVCO Research and Advanced Development Division describes a packaged light source for recording high-speed phenomena with shadowgraph and schlieren systems in its Advanced Equipment Bulletin No. 10. **(Circle EQ RSC #46)**

* * *

PROPULSION TEST FACILITIES, Inc., tells what it can do in a new four-page booklet. The company is a recently-organized subsidiary of MB Electronics. **(Circle EQ RSC #47)**

* * *

CONRAD, Inc., is also offering, free of charge, an open-out, six-page technical data and conversion chart that fits a three-ring binder. Two of the charts list differences between wet and dry bulb readings. **(Circle EQ RSC #48)**

* * *

TRAID Corporation pictures and describes 27 differene types of motion picture and sequence data cameras in a four-page "Camera Selector." The information is laid out in convenient, chart form. **(Circle EQ RSC #49)**

* * *

VARIAN ASSOCIATES' compact strip-chart recorders are detailed in an eight-page brochure. The instruments are of the null-balance potentiometer type. **(Circle EQ RSC #50)**

THE BRISTOL Company has release a new edition of its Bulletin E-11 "Recording Voltmeters and A meters." **(Circle EQ RSC #51)**

* * *

THE ECKEL Corp.'s "Eckoustic Panels are described in a folde "Achievement in Acoustics," whic spells out construction features an sound absorption coefficients. **(Circ EQ RSC #52)**

* * *

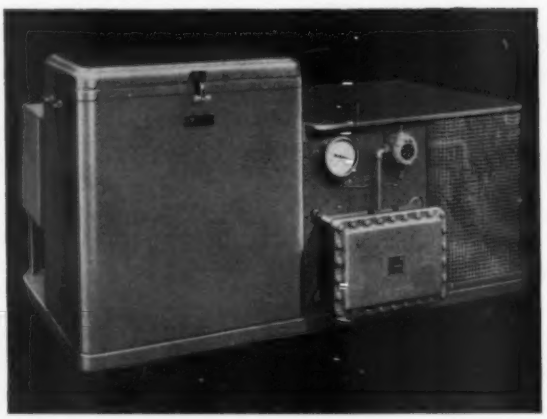
GENERAL ELECTRIC Co.'s Missi and Space Vehicle Department ha published two helpful brochure One tells how the department co ducts its research and developme work. It is 24 pages. **(Circle EQ RS #53.** The other, of 32 pages, d scribes the capabilities of the d partment's environmental facilitie **(Circle EQ RSC #54)**

* * *

FISCHER & PORTER Co. describes i multiple pressure readout system i its artful, 12-page, two-color Catalo 301B1000. The system measures an records hundreds of different pre sures simultaneously with a sing high-accuracy transducer. **(Circ EQ RSC #55)**

* * *

B & K INSTRUMENTS, Inc., has r leased a new, 24-page catalog li ing its complete line of instrumen for measuring sound, vibration an strain. **(Circle EQ RSC #56)**



Production chilling of stabilizing shafts utilizes this Cincinnati Sub-Zero unit, with temperature range of —70° to —150°. Chills 150 lbs. of steel hourly . . . 4000 BTU/hr at —120°F.

Write today for full-line catalog. Or describe your requirements so our Engineering Department can make recommendations.

CHOOSE THE PIONEER

CINCINNATI SUB-ZERO PRODUCTION and CHILLING EQUIPMENT

For 20 years we have been building low temperature testing and storage units. As the most experienced manufacturer in the field today, we take pride in our record for 100% reliability . . . and for building a little more into every unit produced.

Member: Environmental Equipment Institute

CINCINNATI SUB-ZERO PRODUCTS

General Office & Plant

Paddock at Reading Rd. • Cincinnati 29, Ohio

Post Scripts

(Continued from Page 2)

forwarded without charge. A code number address counts as one line.

The form for a free "situation wanted ad" appears on Page 12—preceding our first want ad.

The Environmental Want Ad deadline for the fourth (Oct.) 1959 Quarterly issue is Sept. 10.

Circulation: Reader's Tag

Environmental Quarterly is also embarking on a new quest for readers, and is enlisting the help of present readers in finding them. We're playing a little game called "reader's tag." It goes like this:

If you get Quarterly regularly in the mail, and like it, look around your office and jot down the names and addresses (home addresses, please, if possible), of those of your colleagues (or any other friend you can think of) who you think might like to read Quarterly, too. Use the postage free card bound into this issue, or any handy scrap of paper.

Send the list to EQ's circulation department. If the names you tag are not on our lists, they will be added promptly.

Of course, if you yourself happen to see Quarterly only occasionally, and would like to receive it regularly, send along your own name and home address, preferably on a company letterhead to help identify yourself. Your home address is the price of your own subscription.

Under EQ's new circulation policy, all individual environmental scientists, engineers, educators and students will be getting the magazine free as soon as the current batch of paid subscriptions runs out.

The existing rate, $4 annually in the United States and Canada and $5 elsewhere, continues for non-individual subscribers such as institutions, companies and libraries, and for all readers abroad.

Tag new readers for Quarterly. Your friends and colleagues will be glad you did!

Idea Swap Shop

Last issue, **Environmental Quarterly** inaugurated an "Idea Swap Shop," consisting of questions put to the editor which cannot be answered easily because of the many sources that might have the answer(s). If you have any questions you'd like to try out on EQ's readers, send them along. Here are two from our pending file:

WRM would like more information on transmissibility reports covering whole missile shake tests.

WFV seeks information on sparkgap breakdown voltage for altitudes up to and including 100,000 feet.

WANTED

ENVIRONMENTAL

TEST ENGINEER

TO HEAD

TESTING DIVISION

OF LEADING

EAST COAST TESTING LAB

Environmental Quarterly

Desk "B"

ALL RESUMES CONFIDENTIAL

DO YOU HAVE A NEW COMPONENT, ASSEMBLY OR END ITEM THAT MUST MEET SOME REQUIREMENT IN ENVIRONMENT?
Acton Laboratories, Inc., offers an environmental testing *service*, meeting both commercial and military specifications, to companies: (1) requiring independent certification of tests, (2) not in a position to justify the purchase of expensive environmental equipment, (3) whose own environmental facilities are in use on other projects.
Our facilities, engineers, and teohnicians are available to conduct the entire tests; or you may use our facilities and provide your own engineers or technicians to conduct the performance tests.
For information telephone or write:
ALI

ENVIRONMENTAL BUSINESS...

Investors Smile on Environment Makers

The fickle yet discerning world of finance smiled with favor in recent months on two relatively young firms in the business of environments. The recipients of investors' nods of approval were ITEMCO, Inc., and Associated Testing Laboratories, Inc.

ITEMCO "went public" April 22, less than a year after it went into production. It issued 160,000 shares, which opened in the over-the-counter market at $1 and were quickly snapped up.

● Taking Larger Quarters

Shortly afterward Albert J. Deeb, general manager, announced ITEMCO would soon move to new, larger quarters on Beechwood Avenue, Port Washington, L. I., about a mile from its present site.

"We expect," he said, "to increase business from our current $250,000 annually to a million dollars within a year."

ITEMCO manufactures a line of temp, alt, hum, sand and dust, salt spray and other chambers.

Associated Testing, the other beneficiary of a springtime stock issue, was organized in Caldwell, N. J., in June, 1956, by William Tonkowich, president, and Bernard Novack, vice president. Both were formerly with General Testing Laboratories.

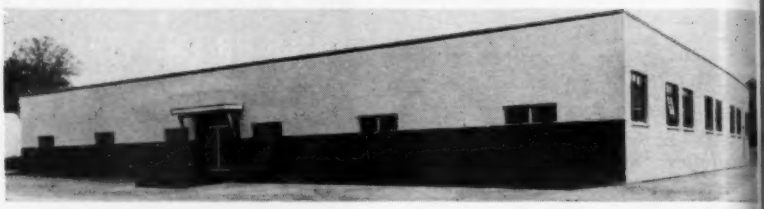
By the end of six months, Tonkowich and Novack had poured $28,200 and endless amounts of time and energy into their venture.

● Proceeds a Half-Million Dollars

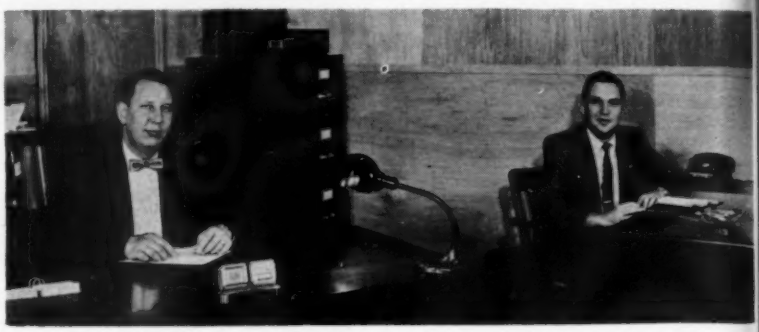
As a measure of ATL's growth, the stock offering, at $3 a share, brought half a million dollars of new investment capital into the company.

ATL has a manufacturing division producing environmental equipment.

Expansion plans include new plant facilities, a wider research program embracing vibration and acoustical equipment, and setting up a testing lab in the Boston area.



Rendition of the new ITEMCO, Inc., plant in Port Washington, on Long Island.



Bill Tonkowich (left) and Bernie Novack, of Associated Testing Laboratories.

New Plant for Ling

Ground-breaking for a new half-million-dollar Ling Electronics, Inc. manufacturing facility at the Anaheim, Calif. plant of the Altec Companies saw three men share a golden shovel. They are (left to right): A. A. Ward, president of Altec, and James J. Ling and Cameron G. Pierce, Ling's chairman and president, respectively. The ceremony took place not long after stockholders approved Ling's acquisition of the Altec group, leader in high fidelity, high-intensity sound systems.

LOX Room Completed by PDL

A liquid oxygen cleaning room has been completed by Propulsion Development Laboratories, Inc., El Segundo, Calif., for sterile cleaning and assembly of precision parts. Located at one of PDL's five plants, the LOX room is dustproof and virtually soundproof and is equipped with special instruments for final testing. It was built to Air Force specifications.

Tenney Expects 15% Sales Hike

Monroe Seligman, president, told Tenney Engineering, Inc., stockholders at their annual meeting that the company expects 1959 to show a 15 per cent increase in sales over the $4.5 million reported last year. He said this would result from orders from environmental chambers coupled with increased volume from new affiliates.

TI Forms Avionics Test Center

Texas Instruments Incorporated has set up an avionics flight test center at Addison Airport, North Dallas, Texas, to centralize ground and flight testing of airborne electronic systems its apparatus division manufactures.

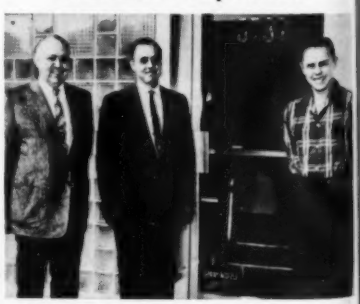
U. S. Testing Gets AF Contract For Combined Environment Study

United States Testing Company, Inc., Hoboken, N. J., has announced receipt of a one-year contract from Wright Air Development Center to explore the feasibility of combined-environment testing.

Current practice of exposures to single environments or to a simple group of environments "rarely matches actual service conditions," the announcement said, adding that important gains can be made by combining factors, such as alternating high and low temperatures coupled with vibration, shock and acceleration.

U. S. Testing said that the study will be done with existing equipment as far as possible, so that "results will be applicable throughout the testing industry without expensive and extensive acquisition of new facilities."

Missimers Expansion



Dale J. Missimer Sr., Dale Jr. and George L. Missimer (left to right) at the entrance to the new Glendale, Calif., plant which has more than doubled engineering, manufacturing and office space of Missimers Incorporated, manufacturer of environmental test chambers and technical refrigeration equipment. "3737" is on San Fernando Road.

EEI Picks Harris, Maps Program

Charles C. E. Harris (Harris Refrigeration Co.), a dean in the business of environments, was elevated to the presidency of the Environmental Equipment Institute, the manufacturers' organization, in Chicago last April. Nick E. Miller (Murphy & Miller, Inc.) was named executive vice president of the group, succeeding Harris in that post, and W. R. Bruskrud (Bemco, Inc.), Alexander Newman (Hudson Bay Co.) and Monroe Seligman (Tenney Engineering, Inc.) were elected directors. Robert J. Jacobson (Cincinnati Sub-Zero Products) is the retiring president.

Harris

The manufacturers' meeting on April 23 coincided with the three-day convention of environmental engineers (See Page 4) and the engineer - sponsored equipment show (See Pages 19 and 22) in the LaSalle Hotel. On April 24 many of the 27 exhibitors at the show were guests of the EEI at breakfast.

Miller

Out of the EEI meeting came new membership and public relations campaigns to be undertaken by General Manager George Wilkinson. Part of the public relations effort will be devoted to the institute's "Seal of Approval" program.

Gold Seal of EEI

Also discussed were plans for a new annual award for the best published paper submitted on any subject in environmental simulation and testing.

The EEI's semi-annual meeting will be held in Atlantic City next November in conjunction with the ARI convention.

Harris, the new EEI president, has been in the refrigeration business since 1927, a year after he arrived in Boston from his native Ireland. He went into business for himself in 1934 and formed Harris Refrigeration in 1940. A —100° F. unit Harris built for M.I.T. in 1938 was probably one of the first low temperature units to use Freon.

Seligman

Newman

Bruskrud

Miller joined Murphy & Miller, a 23-year old company, nine years ago. In 1956 he became sales manager of the environmental products division and in the same year became active in the EEI, first as his company's representative and then as a member of the executive committee.

Tunnel Has 1,000th Firing

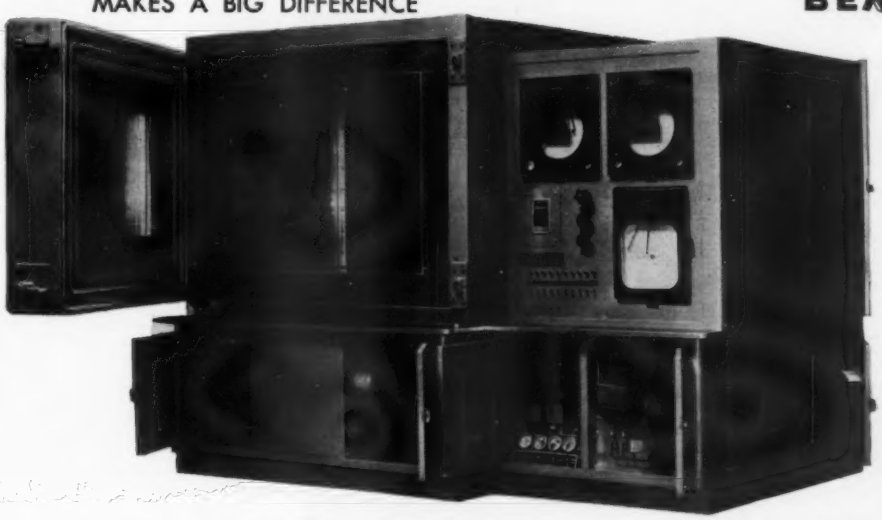
The thousandth firing of General Electric's huge shock tunnel took place at the end of last month. The company's Missile and Space Vehicle department uses the tunnel to simulate some part of a reentering nose cone's environment. The tunnel went into operation in March, 1957.

(More "Business" on Page 36)

Look Inside the Chamber

BEMCO ENGINEERING AND FABRICATION
MAKES A BIG DIFFERENCE

BEMCO INC.



There is no substitute for experience in environmental test equipment design, manufacture and service. Bemco manufactures all types for temperature, pressure, vacuuam, humidity, fungus, salt spray, sunshine, rain, and combined environments.

BEMCO INC. • 11631 VANOWEN STREET • NORTH HOLLYWOOD, CALIF.

NEW ENDEVCO
VIBRATION
SYSTEMS
Featuring: Transistorized charge amplifier and hermetically sealed accelerometer. You can use up to 300 feet of cable between amplifier and accelerometer —with no signal loss.
Complete Endevco system qualifies to Mil E-5272. Temperature range —40°F to +230°F. Frequency response from below 10 cps to above 10 KC. Entire system isolated from ground.
Endevco System Amplifiers and Transducers are described in the "2200" and "2600" literature. Write for your copies today.
dynamic instrumentation
ENDEVCO CORPORATION
Department M
161 East California Boulevard
Pasadena, California

Environmental Business

Liquid Carbonic Acquires Hench Gas Enterprises

Acquisition of the industrial and medical gas business of Hench associated enterprises by General Dynamics Corporation has been announced by Rex L. Nicholson, president of GD's Liquid Carbonic Division.

The deal reportedly involved several million dollars in cash. Frank Pace Jr., chairman of General Dynamics, said it represents "another step" in his company's program to balance defense and commercial profit margins.

The Hench group is active along most of the eastern seaboard and inland to Ohio. Chief products are oxygen, acetylene, argon, nitrogen, nitrous oxide, hydrogen and welding equipment.

Liquid Carbonic, one of the seven major operating units of General Dynamics, is said to be the world's largest producer of carbon dioxide. It will shortly absorb the Hench operations, which include New England Gas Products, Inc., American Oxygen Service Corp., Commercial Gas Corp., Buckeye Oxygen Corp. and Florida Gas & Chemical Corp.

COMPANIES AT WORK

Acton Laboratories, Inc., Acton, Mass., has appointed **S. S. Lee Associates, Inc.,** of 1107C West Broad Street, Falls Church, Va., as representative for ALI's line of electronic laboratory test instruments in the southeast, from Virginia to Mississippi. **D. B. Associates, Inc.,** 3307 Erie Blvd., East, DeWitt (Syracuse), N. Y., has been named ALI rep in northern New York state.

CDC Control Services, Inc., Hatboro, Pa., has changed its name to the **CompuDyne Corporation** as being more descriptive of the company's particular kind of product.

International Radiant Corp., Westbury, N. Y., has set up sales and service offices in Chicago at 5222 West North Ave. and on the West Coast at 150 Baylor Dr., Ventura, Calif. **Harry E. Musgrave** heads the Chicago office; **Robert N. Williams** the one in Ventura. Both were formerly with Bowser Technical Refrigeration.

Torit Manufacturing Co., St. Paul manufacturer of dust collectors, will consolidate operations from three locations at one new plant this summer. William M. West, Torit's president, said manufacturing and engineering facilities will be increased about 25 per cent.

Chicago Surgical & Electrical Co., division of Labline, Inc., has shipped 35 centrifuges in floor and bench type models to the new osteopathic unit of Los Angeles County General Hospital. It is said to be one of the largest single orders of its kind in recent times.

Zero Manufacturing Co., Burbank manufacturer of containers and environmental protection packaging for the missile and electronics industries, reported record sales, profits and per share income in the fiscal year that ended last March 31. Net income after taxes rose to $254,815, or $1.37 per share, as compared with $139,148 or 91c the year before.

(More "Business" on Page 38)

CONRAD Inc.

Subsidiary Crampton Mfg. Co.
Grand Rapids, Michigan

ENVIRONMENTAL TEST CHAMBERS

— 200° to + 1000° F.

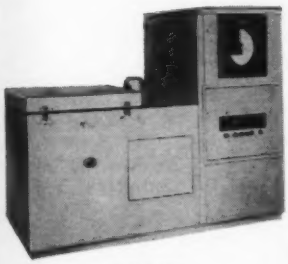
- Temperature
- Altitude
- Humidity
- Vibration
- Sand and Dust
- Explosion
- Rain
- Fungus

Conrad's years of experience and complete engineering and manufacturing facilities are devoted to environmental test chambers — exclusively. We can meet your requirements with one of our stock models, or we will develop chambers of special design and performance for you. All Conrad chambers are designed to comply with military specifications. For information, write or call the main office in Holland or the Conrad representative nearest you. See list of representatives in A-Z section.

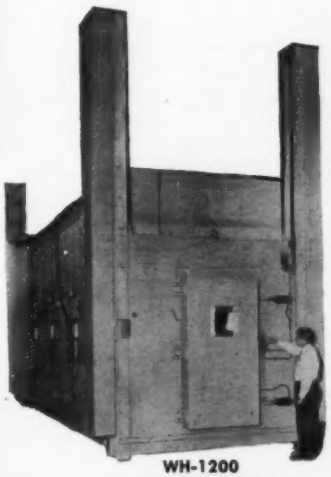
NATIONWIDE SALES AND SERVICE

FD-10
TEMPERATURE-HUMIDITY

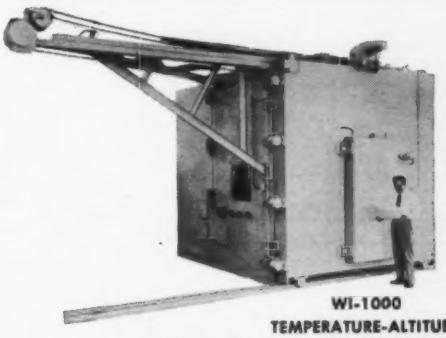
TEMP-RAC "19"
PORTABLE
TEMPERATURE



CB-8 — HIGH-LOW
TEMPERATURE

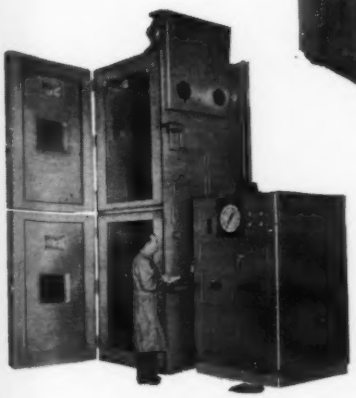


WH-1200
WALK-IN ALTITUDE



WI-1000
TEMPERATURE-ALTITUDE
HUMIDITY-RAIN

EXPLOSION CHAMBER



FB-144 — CABLE TESTER

WBV-275 — TEMPERATURE-VIBRATION

Write For Information

CONRAD Inc.

CONRAD SQUARE
HOLLAND, MICHIGAN

Environmental Business

(Continued from Page 36)

Principals in New Environmental Firms

Ponge

Andrews

Space-Tronics, Inc.

Clark

Itemlab

Rice

PAM Associates

Space-Tronics, Manufacturers' Rep

Newcomers to the manufacturers' rep field with an impressive list of environmental manufacturers are Norman A. Ponge and A. M. Andrews, who have formed Space-Tronics, Inc., at 100 East Old Country Road, Mineola, N. Y.

Ponge was formerly vice president of Burgoyne Testing Labs. Andrews headed Trop-Arctic, Inc., until it was acquired by the Guardite division of American Marietta Company.

Space-Tronics now represents Guardite, L.A.B. Corporation, Industrial Filter & Pump Manufacturing Co. and Grieve-Hendry Co.

(For more info circle EQ RSC #58).

PAM Associates, Noise Specialists

A group of Martin Company experts on shock, vibration and acoustics have organized PAM Associates, Inc., 7315 Harford Rd., Baltimore. Tenney Engineering, Inc., a leading producer of environmental chambers, has acquired a "substantial interest" in the new firm.

J. William Rice Jr., former chief of Martin engineering facilities, is president of PAM. Edward J. Kirchman is vice president-engineering, and Avery L. Owen II is vice president-research.

In addition to creating shock and vibration test equipment, PAM will act as consultants on noise control to the aviation and other industries.

(For more info circle EQ RSC #59).

ITEMLAB Joins Ranks of Testers

ITEMLAB, Inc., has just opened its doors in Port Washington, N. Y., newest in the growing corps of independent commercial environmental laboratories.

In addition to advanced climatic, dynamic and combined testing, ITEMLAB, under General Manager Harry R. Clark, is offering clients a research, design and development program.

Harry Popkin is president of the company. Clark is also vice president. Socrates N. Vavoudis, formerly with General Precision Laboratory, Inc., is director of engineering, and Jerome Greenberg, who had been a quality control chief at Reeves Instrument Co., is sales manager.

(For more info circle EQ RSC #60).

It's Now 'MB Electronics'

MB Manufacturing Co., New Haven Conn., producer of vibration te equipment and associated electron ic apparatus and systems, ha changed its name to MB Electroni because of the importance of ele tronics in the company's growth pi ture. Shown discussing the chang and related expansion plans are (lef to right): Herman E. Goodman, vic president, and George W. Miller, president, of Textron Electronics Inc., MB's parent firm, and George H. Mettler, president of MB.

News Briefs

WASHINGTON — Russian physicists have developed a molecular generator with such stable output that it can power an electric clock accurate within one second in 300 years, according to a U. S. Office of Technical Services translation of a Russian article. Power is supplied by radio waves emitted by molecules of ammonia, which are said to have unusually stable vibrations and never to deteriorate or age.

• • •

WRIGHT AIR DEVELOPMENT CENTER — A thin metal film resistance thermometer—up to 100 times more sensitive to temperature changes than thin film thermocouples—has been devised to measure heat transfer rates in a hypersonic shock tunnel. Its sensitivity may be varied at will by changing the energizing current [illegible] the element.

• • •

SAN FRANCISCO — Quote of th season: "It's time engineers assum much greater responsibility in co munity and national affairs, especia since more and more of them are l ing to top corporate manageme They've confined their interests to much to professional matters in th past."—Howard C. Pyle, new preside of the American Institute of Minin Metallurgical and Petroleum En neers.

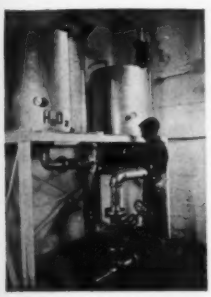
• • •

WASHINGTON—Bureau of Min scientists have succeeded in making casting of molybdenum, a feat d scribed as a major breakthrough in e forts to develop high-temperatu metals for the space age. Molybden melts at 4,748° F.

ENVIRONMENTAL QUARTERLY'S ADVERTISERS

Acton Laboratories, Inc.	33	ITEMCO, Inc.	23
Aerotest Laboratories, Inc.	Inside back cover	Lambert Engineering Company	5
American Research Corporation	17	Ling Electronics, Inc.	Front cover, 9, 10
Belock Instrument Corporation	Inside front cover	Liquid Carbonic Div., General Dynamics Corp.	20, 21
BEMCO, Inc.	35	Murphy & Miller, Inc.	26
Blue M Electric Company	28	Optron Corporation	11
Cincinnati Sub-Zero Products	32	Pure Carbonic Company	29
Conrad, Inc.	37	Rucker Company, The	31
Endevco Corporation	36	Standard Cabinet Co.	15
General Testing Laboratories, Inc.	14	Tenney Engineering, Inc.	Outside back cover
Genisco, Incorporated	1, 27	Thermoseal Glass Corporation	5
Guardite Division, American-Marietta Co.	3	United States Testing Company, Inc.	8
Harris Refrigeration Co.	5		

Thorough planning and pre-test study is a vital phase of creative test engineering.



Hydrogen Peroxide flow testing—flow rates to 150 gpm, static pressures to 3,000 psi.

Aircraft and missile vibration testing—to 20 g's and 2,000 cycles per second.

This is AEROTEST

. . . where *creative test engineering* is a specialty of the house

Aerotest Laboratories, with its outstanding staff of professional test engineers and technicians, supported by modern plant facilities and one of the country's most extensive arrays of standard and special test equipment, has added a new dimension to test laboratory services — *creative test engineering.*

When a vital test program calls for more than the routine performance of standard tests in accordance with standard specifications, you can rely on Aerotest's highly developed skills in *creative test engineering* for the solutions to your really "tough" testing problems.

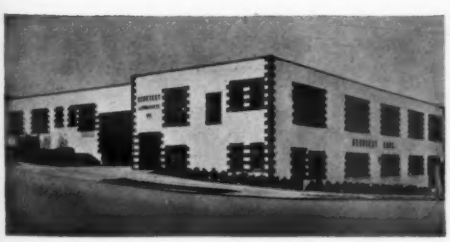
At Aerotest, *creative test engineering* is a specialty of the house, made possible by years of diversified experience, technical imagination and know-how.

General laboratories for testing of electrical and electronic equipment.

Walk-in temperature chamber, −85°F to 250°F, 8' x 8' x 8'.

Temperature-altitude-humidity, −100°F to 250°F, 200,000 ft., 5% to 95% humidity, 10' x 11' dia.

Complete machine shop facilities for fabricating special test fixtures and equipment.



Aerotest maintains two new plants at College Point, N. Y., only 5 minutes from New York's LaGuardia Airport.

Complete functional and environmental testing of electronic, mechanical, pneumatic, hydraulic, avionic and fuel system equipment.

LOW TEMPERATURE	RAIN	HOT FUEL FLOW
HIGH TEMPERATURE	SUNSHINE	HIGH ALTITUDE
FUEL RESISTANCE	ENDURANCE	SAND AND DUST
ENVIRONMENTAL VIBRATION	EXPLOSION	HUMIDITY
CONTAMINATED FUEL	NOISE LEVEL	SALT SPRAY
ACCELERATED CORROSION	SHOCK	IMMERSION
RADIO INTERFERENCE	FUNGUS	ACCELERATION

ROCKET & MISSILE LIQUID PROPELLANT FLOW TESTING

Complete test proposals submitted without obligation.

Write for illustrated brochure of full information on Aerotest facilities and services. **Aerotest Laboratories, Inc. 129-11 18th Ave., College Point, N. Y.**

Aerotest

ENVIRONMENTAL & QUALIFICATION TESTS • DESIGN EVALUATION TESTS
RESEARCH & DEVELOPMENT • PRODUCTION SAMPLING TESTS
TEST EQUIPMENT DESIGN • INSPECTION METHODS • QUALITY CONTROL ANALYSIS

the highest,

the coldest,

the hottest

. . . IN THE SMALLEST *SPACE!*

Tenney-mite STRAT
environmental chamber

Altitudes to 200,000 ft., temperatures from –100° F to +350° F, in only 4 square feet of floor space. Now, any company can own a combined altitude and temperature test chamber . . . without sacrificing much valuable floor space. And the investment, too, is reasonable.

Only Tenney Engineering, world's largest and most experienced creator of environmental equipment, could produce the Tenney-mite Strat. Write for further information.

Write for a descriptive catalog and complete information on Tenney's research and development, engineering consultation, and design services.

Tenney ENGINEERING, INC.

OLDEST AND LARGEST MANUFACTURER OF ENVIRONMENTAL EQUIPMENT

1090 SPRINGFIELD ROAD, UNION, NEW JERSEY • PLANTS: UNION, NEW JERSEY AND BALTIMORE, MARYLAND